Saskatchewan
Agriculture
and Food

ADF

AGRICULTURE DEVELOPMENT FUND

FINAL REPORT

20030409

SOURCES OF RESISTANCE/TOLERANCE TO MYCOSPHAERELLA BLIGHT OF FIELD PEA

Funded by: The Agriculture Development Fund

March 2008

Prepared by: Agriculture & Agri-Food Canada (AAFC)

Final Report

SPG/ADF Project #20030160 / 20030409

March 10, 2008

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Abstract

Studies on mycosphaerella blight on field pea were conducted from 2004–07. High levels of seed infection had little impact on disease severity or seed yield, but reduced seedling establishment. In trials to assess tolerance (a form of resistance), reducing blight severity by applying fungicide did not always increase yield. Variability in these assessments makes tolerance difficult to use in breeding programs. Close relatives of field pea were assessed; several accessions were moderately resistant and likely carry novel resistance genes. Blight reaction was stable across sites, which validates the use of a single aggressive isolate(s) to screen for resistance.

Technical Summary

The proposal for the study was approved in the spring of 2004, but the contract for the project was not signed until November 2004. However, some studies were initiated at Saskatoon and Morden in 2004. Studies were conducted in collaboration with researchers in Saskatchewan, Alberta, Manitoba and Ontario from 2005 to 2007. A study on the impact of high levels of seed infection with *Mycosphaerella pinodes* on subsequent levels of foliar blight was conducted at four sites over two years. Almost no foliar disease developed at a site in southern Ontario (Bradford) where there was little or no background inoculum from adjacent fields. At three sites on the prairies where abundant air-borne inoculum were present (Saskatoon SK, Vegreville AB, Morden MB), seed infection had little impact on subsequent disease development and even less impact on seed yield . We conclude that a program to select for resistance to seed infection in field pea lines (as suggested in Xue et al. 1996) would not likely have an impact on foliar disease severity or pea seed yield on the Canadian prairies. However, very high levels of infection consistently reduced seedling emergence and establishment, so seed testing for germination is recommended. A trial was conducted at sites on the prairies over three years (total of nine station-years) to determine if there were differences in tolerance to mycosphaerella blight in commercial cultivars. Application of fungicide reduced the severity of mycosphaerella blight for almost every cultivar at every site each year, but generally did not have a measurable impact on yield. We conclude that, although tolerance may be present in these lines, this characteristic will be difficult to incorporate into a breeding program due to the high variability associated with assessments. A number of close relatives of field pea were assessed for their reaction to mycosphaerella blight at Morden in 2003, and the 46 most promising lines were assessed again at Morden and Saskatoon in 2004. From these, 26 lines were selected for further assessment at Saskatoon in 2005 and Morden in 2005 - 2007. Many of these selected lines had disease reactions that were as good or better than the (partially) resistant check 'CDC Peko' in one or more field assessments and under controlled conditions using a detached-leaf inoculation test. Based on the high phenotypic diversity in these lines, they are likely to carry novel genes for resistance to *M. pinodes* that will be of value to pea breeding programs. A small study to assess the stability of disease reaction to mycosphaerella blight was conducted at Saskatoon SK and Bradford ON. Partially resistant and highly susceptible cultivars identified using isolates from Alberta were tested in the field at both sites from 2004 - 2006. These trials validated the efficacy of using a single highly aggressive isolates of the pathogen to screen for resistance, even though the pathogen population is known to be genetically diverse. In addition, papers on diseases of field pea have been published in scientific journals, additional papers are in preparation, presentations on these results were made at scientific conferences and extension meetings, and numerous abstracts were published.

Technical Report

Background and Objectives

More than 1.5 million hectares of field pea (*Pisum sativum*) are grown each year in western Canada and mycosphaerella blight is an important constraint to production. Surveys have shown that the disease is present in almost all pea fields in the region, and yield losses due to disease can be high. Preventable crop loss due to mycosphaerella blight is (conservatively) estimated at $22 million per year. Application of foliar fungicide for disease control has produced inconsistent results, and in many cases is not cost-effective.

In most regions of the Canadian prairies, *Mycosphaerella pinodes* is (by far) the dominant species of the ascochyta blight disease complex on pea. For example, no instances of *Ascochyta pisi* or *Phoma pinodella* were reported in surveys in central Alberta (Chang et al. 2007) and production areas in Manitoba (McLaren et al. 2007). Reports for several years from southern Saskatchewan indicate that levels of *A. pisi* are occasionally high on certain cultivars, but *M. pinodes* is the most important pathogen in most areas of Saskatchewan as well (Morrall et al. 2007). As a result, we chose to focus exclusively on *M. pinodes* for this study. In part this was because we had no choice - *M. pinodes* was the dominant (perhaps only) component of disease complex at the field sites that we had available for this study, but also it was the most important component of the complex across the region, so that was where the focus needed to be placed in any case.

Numerous studies have shown that strong single-gene sources of resistance to the predominant races of *Mycosphaerella pinodes* are not available in field pea. However, a recent study in Australia showed that certain wild relatives carry useful levels of resistance to mycosphaerella blight (Wroth 1998). Also, studies in western Canada indicate that some cultivars may have tolerance to this disease (Conner and Xue 2002; Gossen et al. 2001), which could represent a novel approach for disease management. However, this has not been proven, and adapted cultivars have not been adequately assessed. Resistance to seed infection has been identified, and put forward as a potential way to reduce the impact of blight by reducing levels of seed-borne inoculum (Xue et al. 1996). However, the impact of seed-borne inoculum on final disease levels needs to be assessed in more detail. This proposal was conducted in cooperation with projects on management of field pea funded by AARI in Alberta and the Manitoba Pulse Growers Association in Manitoba, and with a project on disease management in processing pea in southern Ontario funded by the Processing Vegetable Growers of Ontario and the Fresh Vegetable growers of Ontario.

The objective of this study was to examine the types of resistance to mycosphaerella blight in field pea. This information is required for the development of successful breeding strategies. A secondary objective was to identify sources of resistance to mycosphaerella blight in close relatives of field pea.

PROJECT ACTIVITIES AND ACHIEVEMENTS

A. Impact of seed infection on stand establishment and blight severity

BACKGROUND: Genetic resistance to seed infection by pathogens in the mycosphaerella blight complex has been known for many years (Skolko et al. 1954), and put forward as a potential way to reduce the impact of blight by reducing levels of seed-borne inoculum (Xue et al. 1996). However, the pathogen is not readily transmitted from infected seed to the foliage of pea plants. Instead, lesions develop on the hypocotyl and base of the epicotyl, and rapidly girdle and kill seedlings (Xue et al. 1996), thereby trapping the pathogen below-ground. The above-ground portions of dead seedlings may subsequently be colonized by the pathogen, and become a source of infection in the current year. Although the impact of seed-borne inoculum on subsequent seed yield has been examined (Hwang et al. 1991), a more detailed study is required to minimize confounding factors such as those associated with seed lots produced in different locations. Numerous studies have been conducted to assess resistance to mycosphaerella blight in foliage of field pea lines (Gossen et al. 2001, Zhang et al 2006, 2007). Although no strong sources of resistance were identified, there are consistent differences in disease reaction, which represent a range of susceptibility rather than a clear delineation between resistant and susceptible.

Various root rot diseases in western Canada reduce establishment of pea (Hwang et al. 2000, 2001, 2007), but large reductions in stand density are required to affect pea yields (Hwang et al. 2006). Seed infection with *M. pinodes* has an impact on seedling establishment (Xue et al. 1996), but its impact on seed yield potential has not been investigated. Provincial recommendations in Saskatchewan identify seed lots with >10% seed infection as unsuitable for planting, but there are no studies to support (or refute) these recommendations.

In contrast to the lack of literature about impact, there are abundant data on the frequency of seed infection by *M. pinodes* on field pea in western Canada (e.g., Morrall et al. 2006, 2007). Although the incidence of infection varies substantially across years and locations, most seed lots produced in western Canada have few or no visible symptoms and less that 5% infection.

To examine the impact of seed infection on subsequent epidemics of mycosphaerella blight, seed lots of a susceptible and partially-resistant cultivar were produced in adjacent blocks. They were managed in the same way (seeding date, weed control, harvest date, etc.), so that they differed only in the level of seed infection. Those seed lots were used in subsequent field tests to assess the impact of seed infection on blight severity and yield. The objective of the trial was to assess the impact of seed infection on epidemic development of mycosphaerella blight. Although differences in susceptibility to seed infection has been reported among pea cultivars (Xue et al. 1996), the impact of different levels of seed infection on subsequent disease development is not well understood. The objective of this trial in 2004 was to produce seed lots of susceptible and resistant cultivars that differed only in the level of seed infection, for use in subsequent field tests to assess the impact of seed infection on blight severity and yield. Those seed lots were used in 2005 to assess the impact of seed infection on subsequent levels of foliar disease. The objective of the trial is assess the impact of seed infection on epidemic development of mycosphaerella blight at sites where air-borne inoculum is present (Vegreville AB, Saskatoon SK, Morden MB) and where it is absent or occurs at very low levels (Bradford ON).

METHODS: In preparation for the trial, seed of field pea cultivars 'Keoma' (highly susceptible to *M. pinodes*) and 'Carneval' (partially resistant) (Xue et al. 2003; Hwang et al. 2006) was produced at Saskatoon in 2003. There were two 20 m x 24 m seed blocks of each cultivar; one

was inoculated with pea crop residue heavily infected with *M. pinodes* and the other was protected with a single foliar application of chlorothalonil fungicide (Bravo 500 FL, Syngenta Crop Protection Canada Inc., Guelph, ON; 1 kg a.i. ha^{-1}) at early flower. The intent of this portion of the study was to develop seed lots that had been produced under uniform conditions (uniform seed source, dates of seeding and harvest, environmental and storage conditions), but that differed as much as possible in incidence of infection with *M. pinodes*.

The proportion of seed infected with *M. pinodes* were assessed on two replicates per seed lot. One hundred seeds per replicate plot were surface sterilized for 2 min in 0.6% NaOCl, air-dried, and placed (5 seeds/dish) on 9-cm-dia. Petri dishes of commercial potato dextrose agar plus streptomycin. Dishes were incubated on the benchtop for 7 days and then the incidence of *M. pinodes* was counted.

In 2003, dry conditions during pod set and seed maturation (Table A-1) severely restricted disease transmission to pods, and levels of *M. pinodes* in the seed were very low (mean 0% for 'Keoma', 2% for 'Carneval'). As a result, this portion of the test was repeated in 2004. Conditions late in the growing season of 2004 were highly conducive to epidemic development. Seed harvested from the inoculated blocks was heavily infected with *M. pinodes* (47% for 'Keoma', 26% for 'Carneval') and seed from the fungicide-treated blocks had lower levels of infection (15 % for 'Keoma', 6% for 'Carneval') (Table A-2).

The seed lots produced in 2003 and 2004 were then utilized in the main study; seed from the inoculated blocks in 2004 was used for the high infection treatment, representing an extremely high level of seed infection. Seed from the fungicide-treated blocks in 2004 represented lots with intermediate levels of disease for the purposes of this trial (although levels are higher than in most lots produced in most years). Seed from 2003 was used as a control for seed-to-seedling transmission of the pathogen. However, it does not represent a true control for seedling establishment because it was produced under different conditions than the seed lots in 2004.

The main study was conducted at four sites in 2005 and 2006, selected to give the widest possible range in environment, climate and pathogen population. At three of the sites, air-borne inoculum of *M. pinodes* was known to be present in abundance due to a long history of production of infected pea crops (Vegreville Alta., Saskatoon Sask., Morden Man.). At the other site (Bradford Ont.), inoculum was expected to be absent or occur at very low levels because there was no history of large-scale pea production in the area. The experimental design was a factorial randomized complete block with four replications. The intent was to assess as wide a range of seed infection levels as possible. The treatments were seed lots of the dry pea cvs. 'Keoma' and 'Carneval' produced at Saskatoon. There were four seed infection level treatments per cultivar; i) heavily infected, ii) intermediate infection, iii) intermediate seed treated with carbathiin + thiabendazole (Crown® at 6 mL kg of seed, a.i. carbathiin + thiabendazole, Bayer Crop Science), and iv) low infection (seed from 2003). Crown fungicide was chosen because it is registered in Canada to reduce seed transmission of similar pathogens on other pulse crops (e.g., *Ascochyta lentis* on lentil (Morrall 1997) and *A. rabiei* on chickpea (Chang et al. 1997; Ahmed et al. 2006)). Crown also has some activity against many of the root rot pathogens commonly found in western Canada, so this treatment would also give an indication of the impact of seedling blight pathogens in each test.

Trials at Saskatoon were conducted on a heavy clay-loam soil at the AAFC Research Farm each year. In Alberta, trials were conducted on a sandy-loam soil at the Alberta Research Council Farm at Vegreville. Trials were also conducted at the AAFC Research Station at Morden on a clay-loam soil. Each plot consisted of four 6-m-long rows (5 m at Morden) seeded at 85 seed per m^2 using a double-disc drill seeder. Spacing between rows was 0.3 m at Saskatoon and Bradford, and 0.2 m at Vegreville and Morden. Spacing between plots was 1.2 m (0.6 at

Morden). In 2005, the site at Morden was abandoned due to flooding for an extended period just after seedling emergence, so two repetitions of the trial were conducted in 2006 at locations separated by 5 km. Seeding operations utilized small-plot seeders, except at Bradford where seeding operations were conducted by hand using an Earthway push seeder.

The basic outline of the study was the same for all four sites. Seedling establishment (counts of the number of seedlings in two adjacent 1-m-long lengths of row at two sites per plot) was assessed about 3 wk after planting. Mycosphaerella blight severity on foliage (0-9 scale, described in Table A-3) was assessed on 10 plants per plot at about 10-20 day intervals, starting at early flowering. The severity of mycosphaerella blight on stems was also assessed one or more times per season over several site-years, using the rating scale proposed by Wang et al. (2006). Also, when powdery mildew (caused primarily by *Erisyphe pisi*) occurred in the test, severity was assessed on a 0-9 scale or as percent leaf area affected. In most site-years, lodging was assessed prior to crop maturity on a 10-point scale (Table A-4) modified from the system proposed by Wang et al. (2006). When the seed was mature, plots were harvested with a combine harvester (except at Bradford, where 1-m^2 areas were picked by hand), and the seed was cleaned, air-dried and weighed. The dates of many critical operations (seeding, rating, harvest) for each site-year are summarized in Table A-5.

Analysis of variance (General Linear Model Procedure of SAS) was used to analyse each response variable at each site. No analysis of data combined across locations was conducted because it was clear without analysis that there would be a large and significant site x year x treatment interaction, which would force analysis based on individual site years.

2005: At Saskatoon, seedling emergence was counted on June 20, % row fullness (assessed as % of area within the row covered by foliage) on July 29, severity of mycosphaerella blight on stems was rated on August 11 and September 09, and powdery mildew severity was assessed on August 11 and 30. At Vegreville, seedling emergence was counted on July 07, and severity of mycosphaerella blight on stems was rated on Aug. 03. At Morden, seeding was delayed by wet soil conditions. The plots were damaged by flooding caused by heavy rain shortly after seeding. Seedling establishment was so uneven and so delayed that the trial was abandoned. At Bradford, seedling emergence was counted on June 10 and again June 17. At the second date, the number of diseased/wilting seedlings per plot were also counted. The severity of mycosphaerella blight on foliage was too low to measure throughout the growing season, so no formal assessments of foliar disease severity were conducted.

2006: At Saskatoon, seedling emergence was counted on June 29, severity of mycosphaerella blight on stems was rated on Aug. 14, and stand lodging and powdery mildew severity were assessed on Aug. 17. The trial was harvested on Aug. 18.

At Vegreville, the trial was planted on May 11. Each plot was 6.0 x 1.2 m , with 0.2 m spacing between rows and four rows per plot. Basagran was applied on June 5 for weed control. Seedling emergence was counted on June 14. Headline fungicide was applied on July 7.

At Morden, trials were established at two locations. Field site 1 was located at the AAFC Morden Research Station, Morden, MB and was planted on May 11 at 85 seeds/m^2 on a clay-loam soil. Site 2 was located at the Morden Nurseries site, approximately 5 km east of the AAFC Research Station at Morden, MB and was planted on May 23 at 85 seeds/m^2 on a sandy loam soil. Each plot consisted of four rows, each 5.4-m-long (later trimmed to 5.0 m), with 0.3 m between rows and 0.6 m between plots. Emergence was counted on June 14, counting two 1.0 metre lengths within the plot. Ten plants per plot were assessed for mycosphaerella blight severity on July 06, 14, 21, and 28, and August 6 at site 1 and on July 17, 23, 31 and August 07

and 13 at site 2. Pea aphid populations required control with Malathion 500EC at 0.9 L/ac on July 18 and 31. Kumulus fungicide was applied on July 31 at 0.6 Kg/ac to control any powdery mildew w that might confound ratings of mycosphaerella blight. Temperature conditions for the region were above average and rainfall was below average. Site 1 was irrigated several times during pod filling. Lodging was evaluated on August 6 (site 1) and 13 (site 2) as a percent, with 0% being fully upright plant stand and 100% being entirely flat plant stand on the ground. Plots were harvested on August 09 at site 1 and August 29 at site 2 and yield was determined.

At Bradford, the plots were seeded on May 10, and seedling emergence was counted on May 25 and June 05. The number of diseased (wilted, dead) seedlings per plot was counted on June 05 and severity of mycosphaerella blight was assessed on June 28. Blight severity remained very low (trace levels) throughout the growing season, and no additional disease assessments were made. The trial was harvested on August 18 and 24.

RESULTS:

2003–04: In 2003, there was little disease development due to hot, dry weather (Table A-1). No disease was present at flowering, so the fungicide treatment was not applied. Seed yield was low (Keoma 1.35 Mg ha^{-1} and Carneval 1.21 Mg) and did not differ between the cultivars (data not shown). At the first rating date in 2004, severity was low (mean = 2.4) and there were no differences among treatments (Table A-2). At the second date, severity was still low (mean = 3.2); but fungicide application reduced severity slightly. At the third rating date, severity had increased substantially (mean = 5.2) and there were differences between the fungicide-treated and non-sprayed treatments for each cultivar (Table A-2). There were no differences in seed yield because of the low number of df in this analysis, but there was a clear negative association between blight severity and seed yield for both cultivars.

2005: At Saskatoon, conditions were quite favourable for the development and spread of mycosphaerella blight (Table A-1). There were no substantial differences in disease severity among the treatments at the two early rating dates, but the treatments for both cultivars with the highest rate of seed infection (HIGH) had slightly higher levels of mycosphaerella blight on foliage at the third and fourth dates (Table A-6) . These differences were reflected in AUDPC values, which were higher for the HIGH treatment than the other three seed infection level treatments for each cultivar. Similarly, severity on stems, which was only assessed later in the season, was higher on the HIGH treatment than the LOW treatment at both rating dates (Table A-7). In addition, seedling establishment was generally higher in the LOW treatment than any other treatment. As a result, seed yield was higher in the LOW treatment than in most or all of the other seed infection treatments for each cultivar.

At Vegreville, conditions were not as favourable for disease development, so overall levels of disease at the end of the season were comparatively low (Table A-6). There were no consistent differences in disease level associated with seed infection treatments on foliage or stems during the season and no differences in AUDPC within cultivar (Tables A-6, A-8). Seedling establishment was consistently higher in the LOW treatment than the other treatments (Table A-9), but there w ere no differences in seed yield within each cultivar.

Weather conditions at Bradford were unusually hot and dry in 2005 (Table A-1). Seedling mortality (assessed as number of wilted or dead seedlings) was not related to seed infection treatment (Table A-10) and only trace levels of mycosphaerella blight were observed in the study throughout the growing season (data not shown). In contrast, the trial at Morden was flooded after seeding and eventually abandoned.

2006: At Saskatoon, there were differences in blight severity among the treatments at the two early rating dates, with the HIGH seed infection treatment developing slightly more disease than the LOW treatment for both cultivars (Table A-11). However, these small differences had disappeared by the final rating date, and only had an impact on AUDPC for one cultivar ('Keoma'). Similarly, there were no differences in severity on stems at the single date of assessment. Seed infection level had no significant impact on seedling establishment, but seedling numbers in the LOW treatment were consistently higher than in the HIGH treatment, and this difference was later supported by differences in % row fullness. Also, the HIGH infection treatment lodged much earlier than the LOW treatment (Table A-12), which could affect seed quality and ease of harvest in commercial operations. Seed infection level did not affect seed yield, but yields in the HIGH treatment were consistently (but not significantly) lower than for the other treatments.

At Vegreville, conditions were conducive for disease development and final disease levels were high. There were no differences in blight severity at the first two ratings dates, but severity was higher in the HIGH level treatment at the final rating date than the other treatments (Table A-12). This difference was also reflected in the AUDPC and in severity on stems. Also, seed establishment was lower for the HIGH treatment than for the other treatments. Also, establishment was lower in the Intermediate treatment with Crown fungicide than the LOW treatment for both cultivars. As at Saskatoon, yields were lower in the HIGH treatment than for the other treatments, but the differences were not significant.

At Morden, disease levels were low throughout the season at both sites. There were no differences in blight severity at any date, and no differences in AUDPC (Table A-13). Seedling establishment was generally lower in the HIGH treatment than for any other treatment at both sites (Table A-14), but treatment did not affect lodging, seed weight, the incidence of discoloured seed or seed yield.

At Bradford, conditions throughout the growing season were hot and dry, and little mycosphaerella blight was observed. There were no differences in blight severity among treatments (Table A-15). We observed that most of the lesions developed high up in the crop canopy, which indicates that the symptoms likely resulted from infection by airborne ascospores, rather than splash-dispersed conidia from lesions within the canopy. Treatment had a substantial impact on seedling establishment for both cultivars; establishment was lowest for HIGH, intermediate for I and I + Crown, and highest for the LOW infection treatment. However, there were no differences in seed yield for cv. 'Carneval', but yield was lower for HIGH than for LOW and I + Crown for cv. 'Keoma'.

There was a substantial epidemic of mildew late in the season at Saskatoon in 2005 (Table A-7) and 2006 (Table A-12), and the disease also developed at low to moderate severity at Vegreville in 2005 (much less severe on'Carneval' than 'Keoma', Table A-9). Taken across all sites and years, both 'Keoma' and 'Carneval' were susceptible to powdery mildew in this trial.

Lodging was assessed prior to harvest at several sites and years. There were no differences among treatments at Vegreville in 2005 (Table A-9) or Morden in 2006 (Table A-14), but lodging was more severe in the HIGH than LOW treatments, with the others intermediate, at Vegreville in 2006 (Table A-12). Seed size was assessed at both sites at Morden in 2006, but there were no differences associated with seed infection treatment (Table A-14).

DISCUSSION:

The rates of seed infection from the initial trial in 2004 were high (mean > 20%), especially after the low levels of infection that had developed in the trial in 2003. Seed infection incidence in

commercial fields in Saskatchewan is generally less than 5%, and almost always lower than 10%, based on many years of reports from seed testing companies (e.g., Morrall et al. 2006). As a result, we chose to hand-sort the "low-disease" seed samples to remove those seeds that were visually discoloured (a symptom of infection by *M. pinodes*) and add those discoloured seeds to the "high-disease' treatment to maximize the differential between the treatments. Therefore, the study compares the widest range of seed infection levels possible for their subsequent impact on foliar disease severity - a treatment with extremely high levels of infection, including a high proportion of discoloured and shrivelled seed (HIGH), a treatment with a high level of infection but no visible symptoms (INTERMEDIATE), the INTERMEDIATE treatment with fungicide seed treatment (I + Crown), and a seed lot with no visible symptoms and little or no seed infection, produced at the same site the previous year. Most commercial producers would not even consider planting a poor seed lot like the HIGH treatment, but wouldn't know that the INTERMEDIATE was heavily infected with *M. pinodes* without a seed test.

The site at Bradford is the only one where air-borne inoculum from adjacent fields were not expected to be present at high levels early in the growing season. The site at Bradford was extremely important to the study because it represents an opportunity to examine the direct impact of seed-to-seedling transmission of *M. pinodes* at a site where the frequency of seedling transmission is likely to be the largest single factor influencing the initiation of the mycosphaerella blight epidemic. As such, it was the site where we were most likely to detect small differences in blight severity early in the season. In addition, even very low levels of seed transmission might have been important at this site because of the potential to introduce the pathogen into an area were it occurs infrequently, if at all.

As stated in the introduction to this chapter, our hypothesis was that the rate of seed-to-seedling transmission of *M. pinodes* was likely to be quite low compared to that of related pathogens like *Didymella rabiei*. For *M. pinodes*, lesions develop on the hypocotyl and base of the epicotyl. These lesions can rapidly girdle and kill seedlings (Xue et al. 1996), trapping the pathogen below-ground and minimizing potential to be dispersed via rain-splash.

At the three sites in the field pea-production areas of the Canadian prairies, differences in blight severity were generally small. At two sites (Saskatoon and Vegreville in 2006), blight severity was highest in the HIGH treatment early in the growing season. At one site (Saskatoon in 2005), blight severity was highest in the HIGH treatment late in the growing season. At three sites (Vegreville in 2005, both sites at Morden in 2006), treatment did not affect blight severity at any time during the season. In all of the assessments at all of the sites, there was little or no difference between the cultivars (selected to represent the widest range possible of susceptibility to this pathogen) and no difference between the LOW treatment and the Intermediate treatments with or without seed treatment. There were no differences in disease levels among treatments at Bradford in either year. However, low levels of disease transmission might have been masked by the unusually dry conditions in southern Ontario over the course of the study. Similarly, conditions were quite favourable for blight development at all three sites where small differences in severity were noted. However, differences among sites were much larger than differences associated with treatment.

One of the factors that was almost always affected by seed infection level was seedling establishment. In seven of eight station years, establishment from the HIGH seed lot was lower than from the LOW seed lot. This would not be surprising to producers who had looked at the seed prior to planting, because the LOW seed lot looked healthy and uniform, while the HIGH seed lot contained a substantial proportion of discoloured and shrivelled seed. The Intermediate seed lot had higher establishment than the HIGH seed for either cultivar in only three station years. However, establishment was significantly lower for the Intermediate than the LOW seed

in six of eight years, which would have surprised some growers because the two lots were visually very similar, and they had been harvested and maintained under similar conditions. Seed treatment with Crown improved establishment in five of eight station years, but often for only one cultivar.

Despite the consistent differences in seedling establishment and occasional differences in other agronomic variables such as mycosphaerella blight severity, seed yield in the LOW treatment was higher compared to the HIGH treatment in only three station years, and for only one of the cultivars in two of those three years. Yield in the Intermediate treatment did not differ from that of HIGH, and was lower than yield of LOW in only two of six station years. There was no clear association between disease levels and yield; yield was affected in one station year when there was a difference in blight severity among the treatments (Saskatoon 2005), and in two station years when disease levels were low and no differences in severity were noted (Vegreville 2005, Bradford 2006). Seed treatment with Crown did not affect seed yield in any station year. These data support a previous study in western Canada that showed that seed treatment did not improve seedling establishment of heavily infected seed lots, and that high rates of seed infection reduced establishment but did not affect yield (Hwang et al. 1991).

CONCLUSION

In most years and at most sites, even the extremely high levels of seed infection used in this trial had little or no impact on subsequent epidemics of mycosphaerella blight, and even less impact on seed yield. However, infection level did have a large and consistent impact on seedling establishment, which could in turn have an important impact on factors such as weed competition in commercial fields. We conclude that breeding for resistance to seed infection would have little or no impact on epidemics of mycosphaerella blight. Also, we conclude that tests of seed germination would be of more practical benefit to producers than tests of the incidence of *M. pinodes* and other seed-borne pathogens in the ascochyta complex on pea.

Table A-1. Long-term (30-year) mean values (LTM) and monthly temperature and precipitation (mm and % of normal precipitation) for the locations utilised in this research project in 2003–07: Saskatoon, SK; Vegreville, AB (Edmonton in 2007); Morden, MB; Bradford, ON.

	Mean temperature (°C)						Rainfall (% of LTM)					
Month	LTM	2003	2004	2005	2006	2007	LTM	2003	2004	2005	2006	2007
Saskatoon												
May	11.5	16.5	8.3	10.2	12.0	11.9	42 mm	32	77	55	123	106
June	15.2	16.7	13.4	14.7	17.0	15.8	61 mm	52	142	272	164	181
July	18.2	19.8	18.0	18.0	20.8	21.8	57 mm	103	138	73	82	29
Aug.	17.3	21.6	14.1	15.7	18.9	16.7	35 mm	102	188	193	95	295
Vegreville												
May	10.5	9.7	7.6	9.9	11.2	10.8	34 mm	129	118	103	162	131
June	14.5	13.8	13.0	13.8	15.5	15.5	64 mm	136	59	86	44	76
July	16.3	17.2	16.4	15.9	18.3	19.8	80 mm	79	105	108	69	61
Aug.	15.8	17.1	13.8	13.4	15.7	14.2	55 mm	78	61	117	71	30
Morden												
May	11.9	13.0	8.5	10.8	13	12.6	63 mm	120	274	130	74	243
June	17.3	17.5	15.5	18	19.1	18.3	81 mm	119	58	205	52	169
July	20.4	20.6	19.2	20.6	22.2	22	73 mm	31	82	88	23	112
Aug.	19.2	21.7	15.1	18.5	20.1	18.3	65 mm	64	115	51	61	91
Bradford												
May	12.7	11.5	12.5	10.8	13.8	12.6	73 mm	140	142	19	89	59
June	17.7	18.9	16.3	21.2	18.4	18.8	76 mm	96	65	81	83	38
July	20.3	20.0	19.3	21.8	21.9	19.2	76 mm	46	121	40	91	36
Aug.	19.2	20.4	17.9	19.9	19.2	19.6	78 mm	98	125	67	50	42

Table A-2. Impact of fungicide application on mycosphaerella blight severity (0-9 scale), seed yield, and seed infection on two field pea cultivars at Saskatoon in 2004.

Cultivar	Fungicide	Mycosphaerella blight severity			Yield (Mg/ha)	% Seed infection
		Aug.06	Aug.16	Aug.27		
Keoma	No	2.8a	3.6a	6.2a	2.14a	37a
	Yes	2.6a	3.0ab	4.8bc	3.11a	22ab
Carneval	No	2.3a	3.3ab	5.4ab	2.09a	27ab
	Yes	2.0a	2.7b	4.2c	3.11a	17b
SE		0.2	0.2	0.3	0.23	2.7

(*a-c*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on the Waller-Duncan K-ratio t Test.

Table A-3. The rating scale (0-9) used to assess foliar disease severity of mycosphaerella blight on field pea and processing pea.

Severity score	Plant canopy position		
	Upper	Middle	Lower
0	F	F	F
1	F	F	L
2	F	F	M
3	F	L	M
4	L	L	M
5	L	M	M
6	L	M	S
7	M	M	S
8	M	S	S
9	S	S	S

F = free of disease, 0% of leaf/stem area with symptoms; L = light infection, 1-20% leaf/stem area with symptoms; M = moderate infection, 21-50% leaf/stem area with symptoms; S = severe infection, 50-100% leaf/stem area with symptoms (Xue et al. 1996).

Table A-4. Rating scale used to assess lodging on field and processing pea.

Score	Description
0	Plants erect, straight, separate rows visible
1	Anomalies in rows, plants starting to lean
2	Partial loss of row structure, stand noticeably shorter than normal.
3	Tops of plants still erect, lower plants decumbent. Upper canopy is still intact.
4	Upper canopy not uniform, but mostly intact
5	Upper canopy beginning to break down. Not all upper stems erect
6	Upper stems decumbent, tops nearer to ground than to base of the stem
7	Most of lower stem is nearly horizontal, pods not in contact with ground.
8	Some pods in contact with ground
9	Most pods in contact with ground

Table A-5. Significant dates for the seed infection trials at four sites in 2005–06.

Year & Location	Seeding date	Mycosphaerella blight assessment dates					Lodging rating	Harvest
		1	2	3	4	5		
2005								
Saskatoon	May18	Jul.08	Jul.28	Aug.10	Aug.30	-	-	Sept.09
Vegreville	May30	Jul.06	Jul.13	Jul.22	Jul.29	Aug.03	Jul.29	Sept.08
Morden	May24	-	-	-	-	-	-	-
Bradford	May26	Jun.28	Jul.18	Jul.29	-	-	-	Aug.26
2006								
Saskatoon	May12	Jul.19	Jul.25	Aug.14	-	-	Aug.17	Aug.18
Vegreville	May11	Jul.05	Jul.21	Aug.14	-	-	-	Aug.24
Morden (1)	May11	Jul.06	Jul.14	Jul.21	Jul.28	Aug.06	Aug.05	Aug.09
Morden (2)	May23	Jul.17	Jul.23	Jul.31	Aug.07	Aug.13	Aug.13	Aug.29
Bradford	May10	Jun.28	-	-	-	-	-	Aug.18

Table A-6. Impact of seed infection with *Mycosphaerella pinodes* on blight severity (whole plant ratings, 0-9 scale), Area Under Disease Progress Curve (AUDPC), and seed yield of two field pea cultivars at Saskatoon and Vegreville in 2005.

Location & Cultivar	Seed infection treatment	Mycosphaerella blight severity					AUDPC	Yield (Mg/ha)
Saskatoon		Jul.08	Jul.28	Aug.10	Aug.30			
Keoma	High	1.0b	2.1a	4.1a	7.8a	-	188a	1.1c
	Intermediate (I)	1.0b	1.8a	3.4bc	7.1b	-	167c	1.4bc
	I + Crown	1.0b	1.9a	2.9d	7.2b	-	162c	1.7ab
	Low	1.4a	1.9a	3.0cd	7.4b	-	168bc	1.9a
Carneval	High	1.0b	2.0a	3.6b	7.4 b	-	175b	1.1c
	I	1.0b	1.8a	2.8d	6.1c	-	147d	1.2c
	I + Crown	1.0b	1.8a	2.8d	6.1c	-	146d	1.1c
	Low	1.0b	1.9a	3.0cd	6.0c	-	150d	1.9a
Vegreville		Jul.06	Jul.13	Jul.22	Jul.29	Aug.03		
Keoma	High	0.4c	1.1a	2.2bc	2.4a	2.9a	48.9b	1.68ab
	I	0.3c	1.0a	2.5abc	2.6a	3.1a	52.1ab	1.81a
	I + Crown	0.5b	1.0a	2.2bc	2.4a	2.8a	48.4b	1.73ab
	Low	0.3c	1.0a	2.1c	2.7a	2.9a	48.8b	1.97a
Carneval	High	0.9a	1.0a	2.4abc	2.7a	3.2a	54.3ab	1.43bc
	I	0.7b	1.0a	2.2bc	2.8a	3.0a	52.0ab	1.32c
	I + Crown	0.9a	1.1a	2.6ab	2.7a	3.1a	56.4a	1.46bc
	Low	0.5b	1.0a	2.7a	2.8a	2.9a	55.3ab	1.82a

(*a-c*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on the Waller-Duncan K-ratio t Test.

Table A-7. Impact of seed infection on seedling establishment (seedlings m^{-2}), row completeness (% cover), severity of mycosphaerella blight on stems (0-9 scale) and powdery mildew severity (0-9 scale) on two field pea cultivars at Saskatoon in 2005.

Cultivar	Seed infection	Seedlings (# m^{-2})	% Cover	Stem severity		Powdery mildew	
				Aug.11	Sept.09	Aug.11	Aug.30
Keoma	High	25c	60c	4.6a	7.9a	3.2a	7.1a
	Interm. (I)	25c	75b	4.1b	6.6b	3.1a	7.1a
	I + Crown	32abc	79b	3.9bc	7.1b	3.1a	6.9a
	Low	45a	91a	3.5cd	6.6b	2.4b	6.8a
Carneval	High	24c	58c	4.4 ab	7.4ab	1.7c	6.2b
	Intermediate	28bc	76b	3.4cd	5.4c	1.2d	5.6c
	I + Crown	25c	78b	3.3d	5.4c	1.5cd	5.9bc
	Low	40ab	90a	3.3d	5.2c	1.1d	5.4c

(*a-d*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on the Waller-Duncan K-ratio t Test.

Table A-8. Impact of seed infection on severity of mycosphaerella blight on stems (0-9 scale) and Area Under Disease Progress Curve (AUDPC) in a field trial at Vegreville in 2005.

Cultivar	Seed infection	Severity on stems					AUDPC
		Jul. 6	Jul. 13	Jul. 22	Jul. 29	Aug. 3	
Keoma	High	0.03a	0.3a	1.7a	1.9a	2.6a	34.3a
	Interm. (I)	0.0a	0.4a	1.7a	2.0a	2.7a	34.9a
	I + Crown	0.0a	0.4a	1.8a	1.8a	2.5a	34.7a
	Low	0.0a	0.4a	1.8a	2.0a	2.6a	36.2a
Carneval	High	0.05a	0.5a	1.8a	1.9a	2.6a	35.9a
	I	0.0a	0.3a	1.6a	2.0a	2.7a	33.8a
	I + Crown	0.03a	0.5a	1.8a	2.1a	2.8a	38.3a
	Low	0.0a	0.5a	1.9a	2.1a	2.6a	38.1a

(*a*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on the Waller-Duncan K-ratio t Test.

Table A-9. Impact of seed infection on seedling establishment (plants/m^2), powdery mildew severity (0-9 scale) and lodging in two field pea cultivars at Vegreville in 2005.

Cultivar	Seed infection	Plants/m^2	Powdery mildew	Lodging
Keoma	High	41.7cd	2.8a	2.8a
	Interm. (I)	35.9de	2.3a	3.0a
	I + Crown	44.6bc	2.5a	2.8a
	Low	55.8a	2.5a	2.5a
Carneval	High	32.6e	0.8b	2.8a
	I	39.3cde	0.8b	2.5a
	I + Crown	40.8cd	0.8b	2.8a
	Low	51.0ab	0.8b	2.0a

Note: Seedling establishment was assessed on July 7, lodging on July 29, and powdery mildew severity on August 03.
(*a-e*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on the Waller-Duncan K-ratio t Test.

Table A-10. Impact of seed infection with *Mycosphaerella pinodes* on seedling establishment (plants/m row), disease incidence (counts of wilted or dead seedlings per row), and seed yield of two field pea cultivars at Bradford ON, 2005.

Cultivar	Seed infection	Seedling establishment		# Wilted/dead seedlings	Seed yield (Mg/ha)
		Jun.10	Jun.17		
Keoma	High	10d	10 e	1.3 b	2.2 ab
	Intermediate (I)	17c	18 cd	2.3 b	2.0 ab
	I + Crown	16cd	13 de	3.0 b	1.5 ab
	Low	38a	33 a	8.5 a	1.1 b
Carneval	High	13cd	13 de	0.8 b	3.6 a
	I	17c	17 cde	3.0 b	1.5 ab
	I + Crown	25b	22 bc	2.5 b	2.3 ab
	Low	30b	29 ab	2.0 b	3.3 ab

Note: The number of diseased seedlings was assessed on June 17, and seed was harvested September 16.
(*a-e*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on the Waller-Duncan K-ratio t Test.

Table A-11. Impact of seed infection with *Mycosphaerella pinodes* on mycosphaerella blight severity (0-9 scale) and area under the disease progress curve (AUDPC), severity on stems and seed yield of two field pea cultivars at Saskatoon and Vegreville in 2006.

Location & Cultivar	Seed infection	Mycosphaerella blight severity			AUDPC	Stem severity	Yield (Mg/ha)
Saskatoon		Jul.19	Jul.25	Aug.14			
Keoma	High	2.1a	2.4a	6.1a	98.1a	6.3a	0.99a
	Interm. (I)	1.8bc	1.9bc	6.0a	89.9ab	5.7a	1.28a
	I + Crown	1.7bcd	2.0b	5.8a	88.6ab	5.8a	1.32a
	Low	1.7bcd	1.9b	5.5a	85.0b	5.7a	1.08a
Carneval	High	2.0ab	2.1b	5.5a	87.8b	6.0a	0.90a
	I	1.6de	2.0b	5.5a	85.0b	5.8a	1.79a
	I + Crown	1.6cde	1.8bc	5.3a	81.5b	5.9a	1.84a
	Low	1.4e	1.7c	5.4a	80.5b	5.9a	1.51a
Vegreville		Jul.05	Jul.21	Aug.14			
Keoma	High	3.0a	3.7a	8.5a	200.4a	nd	0.19a
	I	2.6a	4.1a	7.9ab	197.8ab	nd	0.55a
	I + Crown	2.5a	4.0a	6.6c	180.2c	nd	0.31a
	Low	2.6a	3.9a	7.3bc	188.0a-c	nd	0.39a
Carneval	High	2.9a	4.1a	7.8ab	200.5a	nd	0.26a
	I	2.4a	4.2a	6.6c	183.4c	nd	0.35a
	I + Crown	2.5a	3.8a	6.8c	177.6c	nd	0.42a
	Low	2.4a	4.0a	6.6c	178.8c	nd	0.40a

Note: Stem severity assessed on August 14.
(*a-e*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on the Waller-Duncan K-ratio t Test. nd = not done.

Table A-12. Impact of seed infection with *Mycosphaerella pinodes* on seedling establishment, row fullness (% area covered with foliage), severity of powdery mildew and lodging in two field pea cultivars at Saskatoon and on seedling establishment at Vegreville in 2006.

Cultivar	Seed infection	Plants (m^{-2})	Cover (%)	Powdery mildew (%)	Lodging (0-9)	Vegreville (plants/m^2)
Keoma	High	59a	44c	38a	3.5a	16.5d
	Intermediate (I)	57a	59abc	23ab	1.0bc	33.5abc
	I + Crown	57a	59abc	30ab	2.0abc	29.2bc
	Low	67a	69ab	23ab	1.3bc	36.2a
Carneval	High	52a	47bc	33ab	2.5ab	19.3d
	I	60a	70a	25ab	1.0bc	34.3ab
	I + Crown	60a	79a	18b	0.5c	28.8c
	Low	63a	79a	25ab	0.5c	37.2a

Note: % Cover rated on August 17.
(*a-d*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on the Waller-Duncan K-ratio t Test.

Table A-13. Impact of seed infection on severity of mycosphaerella blight (whole plant ratings, 0-9 scale), AUDPC and seed yield at Morden in 2006.

Cultivar	Seed infection	Mycosphaerella light severity					AUDPC	Yield (Mg/ha)
Site 1		Jul.06	Jul.14	Jul.21	Jul.28	Aug.06		
Keoma	High	1.0a	1.7a	2.0a	2.3a	2.3a	59.7a	3.50b
	Interm. (I)	1.0a	1.7a	2.2a	2.5a	2.5a	64.1a	4.11ab
	I + Crown	1.0a	1.7a	2.2a	2.7a	2.7a	67.2a	6.98ab
	Low	0.7a	1.5ab	2.2a	2.5a	2.5a	61.2a	4.25ab
Carneval	High	1.0a	1.0b	2.0a	2.2a	2.2a	53.6a	4.13ab
	I	1.0a	1.5ab	2.5a	2.5a	2.5a	64.0a	4.49a
	I + Crown	0.7a	1.5a	2.0a	2.2a	2.2a	56.4a	4.26ab
	Low	1.0a	2.0a	2.2a	2.2a	2.2a	62.9a	4.38a
Site 2		Jul.17	Jul.23	Jul.31	Aug.06	Aug.13		
Keoma	High	2.0a	2.0a	2.5a	2.5a	2.5a	71.7a	2.45a
	Interm. (I)	1.7a	2.2a	2.5a	2.5a	2.5a	72.6a	2.85a
	I + Crown	1.5a	2.2a	2.2a	2.2a	2.2a	66.7a	2.87a
	Low	1.7a	2.0a	2.2a	2.2a	3.2a	70.4a	2.91a
Carneval	High	1.7a	2.0a	2.0a	2.0a	3.2a	66.6a	2.97a
	I	1.7a	2.2a	2.5a	2.5a	3.0a	74.9a	3.02a
	I + Crown	1.7a	2.2a	2.2a	2.2a	3.5a	73.4a	3.55a
	Low	1.7a	2.0a	2.0a	2.0a	3.0a	65.5a	3.35a

(*a-d*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on the Waller-Duncan K-ratio t Test.

Table A-14. Impact of seed infection on seedling establishment (plants/m^2), lodging, % discoloured seed, and seed weight (per 200 seeds) at Morden in 2006.

Cultivar	Seed infection	Plants/m^2	Lodging	Discoloured seed (%)	Seed wt. (g)
Site 1					
Keoma	High	38cd	57ab	1.7a	34.6b
	Interm. (I)	46bc	65a	0.5a	35.5ab
	I + Crown	53ab	62a	0.0a	34.9ab
	Low	53ab	55ab	0.3a	34.8ab
Carneval	High	32d	17c	0.3a	35.5ab
	I	57a	25c	0.5a	37.2a
	I + Crown	56a	22c	0.5a	37.2a
	Low	51ab	37bc	1.0a	36.6ab
Site 2					
Keoma	High	45a	62b	7.7b	28.1a
	I	50a	77a	7.2b	29.4a
	I + Crown	49a	72ab	9.2b	28.9a
	Low	52a	77a	14.2a	29.0a
Carneval	High	44a	17d	1.5c	28.8a
	I	52a	32c	1.2c	28.0a
	I + Crown	50a	25cd	0.7c	27.4a
	Low	50a	25cd	2.2c	30.5a

(*a-d*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on Waller-Duncan K-ratio t Test.

Table A-15. Impact of seed infection with *Mycosphaerella pinodes* on seedling emergence and establishment (plants/m row), severity of mycosphaerella blight, and seed yield (g m^{-2}) of two field pea cultivars at Bradford ON, 2006.

Cultivar	Seed infection	Plants (per m row)	Blight severity	Yield (g)
Keoma	High	18d	1.2bc	217b
	Intermediate (I)	22d	1.7ab	246ab
	I + Crown	28c	2.1a	299a
	Low	47a	2.0a	291a
Carneval	High	22d	0.4c	304a
	I	33c	0.4c	274ab
	I + Crown	31c	0.5c	308a
	Low	38b	0.9c	309a

Note: Seedling establishment assessed June 05, blight severity on June 28.
(*a-d*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on a Waller-Duncan K-ratio t Test.

B. Assessment of tolerance in pea cultivars

BACKGROUND: The results of several studies in western Canada indicate that certain cultivars, especially those developed in western Canada under continuous (although often unintended) selection pressure for mycosphaerella blight, may have tolerance to mycosphaerella blight (Morrall et al. 1977; Gossen et al. 2001; Conner and Xue 2002). Tolerance differs from conventional resistance, in that the tolerant lines develops as much disease as a susceptible line, but the disease causes less loss in yield than for a susceptible line. Tolerance could represent a novel approach for disease management. However, the existence of tolerance has not been demonstrated conclusively.

METHODS:

The experimental design was a split-plot design with four replications, with cultivars as main plots and fungicide vs. control as subplots. There were nine commercial field cultivars (four cvs. that represent the least-susceptible commercial cultivars available; 'Nitouche', 'CDC Mozart', 'CDC Montero', 'DS Admiral'; four cvs. highly susceptible; 'Highlight', 'Alfetta', 'SW Salute', 'CDC Handel'; and one putative tolerant cultivar; Carneval), with resistance assessments base on provincial recommendations (Anon. 2005) and reaction in previous fungicide trials (Gossen et al. 2001). Cultivars 'Alfetta', 'Carneval', 'CDC Handel', 'CDC Mozart', 'DS Admiral', 'SW Salute' and 'Highlight' are all yellow-seeded, whereas 'CDC Montero' and 'Nitouche' have green seed. At Saskatoon, a low rate of fungicide (chlorothalonil, Bravo 500, Syngenta Crop Science Canada @ 0.3 kg a.i. ha^{-1}) was applied in 250 L/ha spray volume using a CO_2 backpack sprayer equipped with four XR TeeJet 8002 VS nozzles at 240 kPa every 7–14 days starting in early July, and compared with a non-sprayed control. At the other sites, a similar package for application was used, with minor differences to accommodate local conditions and equipment.

At Saskatoon, disease developed very slowly in 2005, so all of the plots were inoculated with infested pea residue (collected the previous year) late in July. In 2006 and 2007 (and for all three years in Alberta), the non-sprayed only plots were inoculated with infested crop residue to maximize the difference in disease severity between the fungicide-treated and non-treated plots for each cultivar. The trials were not inoculated at Morden. Yield differentials between the Bravo-treated and control treatments were not as large as desired in 2005-2006, so the half-rate of Bravo treatment was replaced with a full rate of Headline (a more expensive, but highly efficacious strobilurin fungicide) in 2007.

The trials were conducted at several sites each year, distributed across the pea-production area of the Canadian prairies to give the widest possible range in environment, climate and pathogen population. Trials at Saskatoon were conducted on a heavy clay-loam soil at the AAFC Research Farm each year. Each plot consisted of four 6.0-m-long rows, with 0.3 m between rows and 0.6m between plots. In Alberta, trials in 2005 and 2006 were conducted on a sandy-loam soil at the Alberta Research Council Farm at Vegreville, and in 2007 were conducted on a clay-loam soil at the Alberta Agriculture and Food farm near Edmonton. Trials were also conducted at the AAFC Research Station at Morden from 2005–2007 on a clay-loam soil. Each plot consisted of four rows, each 5.4-m-long (trimmed to 5.0 m), with 0.3 m between rows and 0.6m between plots. Pea seed was direct seeded (80-85 seed per m^2) using a double-disc drill seeder. Seedling establishment (seedlings/1.0-m of row at 2 sites per plot) was counted about 3 wk after planting. At each rating date, disease severity of mycosphaerella blight was assessed on 10 plants per plot using the Xue 0-9 scale. At some sites, severity on stems was also rated at regular intervals using a 0 - 9 scale, where 0 is no disease and 9 represents a dead plant (Wang et al. 2006). The Area Under the Disease Progress Curve (AUDPC) was calculated for each plot, to provide a single

value that would summarize disease pressure in that plot. When present, powdery mildew (*Erisyphe pisi*) was assessed on 10 plants per plot using the 0-11 Horsfall-Barratt scale. Shortly before harvest, lodging was assessed on a 0-9 scale, where 0 = all plants upright and 9 = all pods in contact with soil, as previously described. Seed was mechanically harvested and yield was determined after drying and cleaning the seed from each plot.

Analysis of variance using the General Linear Model Procedure of SAS was conducted on each response variable. To facilitate a comparison of the impact of mycosphaerella blight on the yield of each cultivar across station years, the percentage reduction in disease severity associated with fungicide application and the resulting percentage increase in seed yield was calculated for each cultivar at each site. There was no association between resistance designation of cultivars and the pattern of disease reaction or yield reduction, so no further analysis was attempted.

2005: At Saskatoon, pea crop residue collected the previous year from a trial that was heavily infected with *M. pinodes* was distributed uniformly throughout the plots on July 22. Fungicide was applied on July 25 and Aug. 10. Plant counts were made on June 20. Mycosphaerella blight severity was assessed on July 28, August 12 and September 08, and severity on stems was rated on August 15 and September 09. Powdery mildew was assessed on July 28 (no powdery mildew present at this time) and August 15. Lodging was rated on August 15. Plots were harvested on September 09.

At Vegreville, seeding was delayed by wet soil conditions; the trial was seeded on May 30. The non-treated fungicide plots were inoculated with infected pea residue on June 20 to promote disease. The fungicide treatment (Bravo) was applied on July 4 and 25. Basagran was applied to all plots on July 8 for weed control. Seedlings were counted on July 07. Mycosphaerella blight foliar ratings were done on whole plants and stems on July 06, 13, 22, and 29, and August 03. Lodging was rated on July 29. Severity of powdery mildew was recorded on July 22 and 29, and August 03, but only the last reading is presented. The plots were harvested on September 21.

At Morden, seeding was delayed by wet soil conditions. The plots were seeded on May 24, but were damaged by flooding caused by heavy rain shortly after seeding. Seedling establishment was so uneven and so delayed that the trial was abandoned.

2006: At Saskatoon, the study was planted on May 12. Seedlings were counted on June 26. The fungicide treatment (Bravo) was applied on July 17 and 27. Mycosphaerella blight severity on foliage was assessed on July 26, and August 04 and 17. Severity on stems was rated on August 02 and 17. Powdery mildew severity and lodging were assessed on August 17. Most plots were harvested on August 17–18, but some of the cultivars were left to mature until August 28 and yield was determined.

At Vegreville, the study was planted on May 11. Seedlings were counted on June 14. Mycosphaerella blight severity on foliage was assessed on July 5 and 21, and August 14. The plots were harvested on August 24 and yield was determined.

At Morden, the study was grown at two locations. Field site 1 was located at the AAFC Morden Research Station, Morden, MB and was planted on May 11. Site 2 was located about 5 km east of the AAFC Research Station on a sandy loam soil. It was planted on May 23. Seedling emergence/establishment data was collected on June 14. Fungicide (Bravo) was applied on July 10 and 20 at 0.60 L/ac. Mycosphaerella infection occurred naturally by air-borne inoculum from adjacent areas of pea crop residue. Mycosphaerella blight severity was assessed on July 06, 14, 21 and 28, and August 6 at site 1 and on July 17, 23 and 31, and August 07, and 13 at site 2. Lodging was evaluated on August 06 (site 1) and August 13 (site 2), with 0° being fully upright plant stand and 90° being entirely flat plant stand on the ground. Pea aphid populations required control with Malathion 500EC at 0.9 L/ac on July 18 and 31. Kumulus fungicide was applied on

July 31 at 0.6 kg/ac to control any powdery mildew, which might confuse an accurate rating of mycosphaerella blight. Temperature conditions for the region were above average and below average rainfall. Site 1 had applications of irrigation during pod fill. Plots were harvested on August 09 at site 1 and August 28 at site 2 and yield was determined.

2007: Trials were conducted at the three sites as in 2005-06, except that the site at Vegreville was relocated to the Alberta Agriculture and Food Research Farm at Edmonton. At Saskatoon, the study was planted on May 11. Seedlings were counted on June 29. Pea crop residue heavily infected with *M. pinodes* was distributed on July 09. Fungicide (Headline) was applied on July 16 and 30 at 0.16 L/ac. Mycosphaerella blight severity on foliage was assessed on July 13, and August 02 and 13. Severity on stems was rated on August 02 and 13. Powdery mildew severity was rated on Aug. 06. Lodging was assessed on August 06 and 13. Plots were harvested on August 15, seed was air-dried and cleaned, and yield was determined .

At Edmonton, the study was planted on May 23. Seedlings were counted on June 13. Infected pea residue was distributed, and Headline fungicide was applied twice. Blight severity on whole plants was assessed on July 06, 16 and 27, and August 21. Plots were harvested on Sept. 24 and yield was determined.

At Morden, the study (one location) was planted on May 10. Seedling establishment was counted on June 12. Headline was applied on July 12 and 20. Mycosphaerella blight severity was assessed on July 02, 11, 19 and 25, and August 01 and 13. Plots were harvested on August 23 and yield was determined, together with seed weights for 200 seeds.

RESULTS:

2005: At Saskatoon, weather conditions were quite suitable for development of mycosphaerella blight and disease levels at the end of the season were high (Table B-1). Fungicide application produced a small reduction in blight severity on all cultivars, as measured by AUDPC on both foliage and on stems. However, fungicide application only increased seed yield for one cultivar ('CDC Mozart'). Fungicide application reduced the severity of powdery mildew on three cultivars ('Nitouche', 'Alfetta', 'Carneval'), but had no impact on lodging of any cultivar (Table B-2).

At Vegreville, conditions were too dry for development of mycosphaerella blight and disease levels remained low throughout the season. Fungicide application reduced blight severity, assessed as AUDPC on foliage for 8 of 9 cultivars (Table B-3) and all 9 cultivars for stems (Table B-4) , but had a significant effect on yield for only one cultivar. As at Saskatoon, the only cultivar for which yield was affected was CDC Mozart, but yield was reduced by fungicide application at this site. Fungicide application reduced the severity of powdery mildew on two cultivars ('Nitouche', 'Alfetta'), and reduced lodging on cv. 'Alfetta' (Table B-5).

At Morden, the trial was abandoned due to flooding that occurred after seeding and resulted in uneven seedling establishment.

2006: At Saskatoon, mycosphaerella blight severity throughout the growing season was low to moderate. Foliar application of Bravo consistently reduced the severity of mycosphaerella blight, based on foliar severity and AUDPC for both foliage and stems (Table B-6). However, there was no impact on yield for any cultivar.

Foliar application of fungicide reduced the severity of powdery mildew on cv. 'Alfetta' (Table B-7), but had no impact on yield. Also, application of Bravo consistently (but not significantly) reduced or delayed lodging, possibly through an impact on early-season infection.

At Vegreville, blight severity was also low to moderate throughout most of the growing

season. Fungicide application reduced severity for 7 of 9 cultivars (the resistant cvs. 'Nitouche' and 'CDC Mozart' were not affected), but only had an impact on yield of cv. 'CDC Montero, where yield was reduced by application of fungicide (Table B-8).

At Morden, blight severity was low throughout the growing season. There were no differences in mycosphaerella blight severity associated with fungicide application at either site, no differences in lodging, and differences in yield for only one cultivar ('Carneval') at only one site (Tables B-9 to B-12).

2007: At Saskatoon, mycosphaerella blight severity throughout the growing season was low to moderate, but application of Headline fungicide reduced blight severity at the final rating date and AUDPC for both foliage (Table B-14) and stems (Table B-15) for all cultivars and increased yield for 3 of 9 cultivars ('CDC Mozart', 'Highlight', 'SW Salute'). It also reduced lodging for several cultivars and reduced the severity of powdery mildew for cv. 'Nitouche'.

At Edmonton, mycosphaerella blight severity was very low initially, but increased to moderate levels at the final rating date. Application of Headline fungicide reduced blight severity at the final rating date and for AUDPC (Table B-15), but only increased seed yield for cv. 'CDC Handel'.

At Morden, blight levels were low to moderate throughout the growing season (Table B-16). Application of Headline reduced AUDPC slightly for 5 of 9 cultivars, but had no impact on yield or seed weight (Table B-17).

The percent reduction in mycosphaerella blight severity (using AUDPC of foliage) and percent increase in yield associated with fungicide application for each cultivar and station-year were calculated (Table B-18). There was no clear association between reduction blight severity and yield.

DISCUSSION

Mycosphaerella blight is one of the most common diseases of pea in western Canada. It occurs in almost every commercial field (and on processing pea and in home gardens) every year, and can cause substantial losses in seed yield and (occasionally) quality. No strong sources of resistance have been identified in *Pisum sativum*, but there are differences in susceptibility among pea lines (Zhang et al. 2006, 2007; Zhang and Gossen 2007). In addition, previous reports (Gossen et al. 2001; Conner and Xue 2002) have indicated that tolerance might occur in some field pea lines, especially those developed in western Canada under selection for yield with disease pressure occurring almost every year.

In the present study, repeated application of low rates of fungicide (to minimize blight severity) was compared with a nontreated control for each cultivar. In some station-years, the non-treated control treatments were inoculated with infected pea crop residue to increase blight severity. Four of the cultivars were highly susceptible to *M. pinodes*, four were less susceptible (designated as 'partially resistant' in the tables) and there was one cultivar ('Carneval') where tolerance was suspected based on previous studies in Saskatchewan (Gossen et al. 2001). The trial was conducted at three sites, representing the major pea production areas of western Canada, from 2005 to 2007. In 2007, the protectant fungicide Bravo was replaced with a new, more efficacious fungicide (Headline) that has both protectant and systemic activity. As a result, the differential in blight severity between the treated and the control treatments for each cultivar were larger in 2007 than in 2005 or 2006, but the pattern of response did not change. In 7 of 9 station-years, fungicide application significantly reduced blight severity, but yield was significantly affected (for even 1 of 9 cultivars) in only 4 of 9 station years. There was no clear or consistent association between blight severity and yield for any cultivar, or between reduction

in severity and increase in yield associated with fungicide application. One interesting observation was that there was no clear pattern of difference in disease reaction among cultivars rated as having a 'Fair to Good' reaction to mycosphaerella blight and those that had a 'Poor' Rating in the recommendations put out by the Saskatchewan Department of Agriculture and Food (Anon. 2005).

The lack of correspondence between severity of mycosphaerella blight and yield was unexpected. The ascochyta complex has been shown to have a large impact on pea seed yield in some years (Wallen 1965; Warkentin et al. 1996), and this was substantiated in the current trial at Saskatoon in 2004, where fungicide application increased yield in two cultivars by almost 30% (Table A-2). Several factors may have an important impact on the association (or lack of association) between severity and yield. The most obvious factor is final disease severity - at several sites (e.g., all three years at Morden) the final levels of disease were moderate to low, and so disease pressure was not sufficient to cause measurable yield loss. In almost every other site-year in the study, weather conditions after crop canopy closure were warm and dry, and so were not conducive to development of mycosphaerella blight. As a result, disease levels remained low until late in the season, when cooler, wetter conditions during pod filling finally pushed blight severity into the high range (> 6). This late increase in foliar disease severity likely occurred too late to have a measurable impact on yield. Across all of the trials, season-long disease severity (as measured by AUDPC) was low and differences associated with fungicide application were small. Also, even though foliar disease levels were consistently reduced by fungicide application, the impact of fungicide was even smaller on stems than foliage (in the limited number of situations where it was assessed). This supports the results of a previous study (Wang et al. 2005), where lodging had a larger impact on blight severity and yield loss than fungicide application. However, we suggest that blight severity, lodging and yield loss may be more closely related than previously thought.

In the current study, increases in mycosphaerella blight severity late in the season had little or no impact on yield, but did occasionally increase lodging. A lodged crop provides a humid environment that is ideal for a rain-splash dispersed, moisture-loving pathogen like *M. pinodes*. Lesions on stems weaken the stems, and so increase lodging, and lodging creates the conditions for faster disease development. These two factors, acting together, are likely responsible for the high yield losses that can occur when blight becomes severe relatively early in the season. We also suggest that cultivars like 'Carneval', which have a strong stem, are less likely to lodge under a given disease pressure than lines with a weaker stem, which may be the mechanism that underlies the blight tolerance that has been reported for some cultivars.

This supports the results of a previous study that showed that the mean increase in yield of two applications of Bravo per season was only 6% (Xue et al. 2003).

CONCLUSION

Although tolerance may exist in some or all of these cultivars, variation associated with measurement of both disease severity and yield was to high to permit consistent identification of cultivars with tolerance. This high level of variability means that breeding for tolerance is unlikely to be practical. However, breeding programs that focus on yield can still capture benefits from this kind of resistance by testing at sites where blight is common.

Table B-1. Impact of fungicide (Bravo) application on severity of mycosphaerella blight (whole plant ratings, 0-9 scale), Area Under Disease Progress Curve (AUDPC) on whole plants and stems, and seed yield for cultivars with a range of reactions to blight at Saskatoon in 2005.

Cultivar	Bravo appl.	Blight severity			AUDPC	AUDPC (stems)	Yield (Mg/ha)
		Jul.28	Aug.12	Sept.8			
Partially resistant							
Nitouche	yes	1.9	2.2	6.8	**154**	**128**	1.44
	no	2.0	3.0	7.7	**188**	**150**	1.53
CDC Mozart	yes	2.1	2.1	7.2	**157**	**132**	**3.10**
	no	2.0	2.6	7.9	**176**	**159**	**2.61**
CDC Montero	yes	1.8	2.1	7.1	**153**	**129**	2.09
	no	1.8	2.6	7.8	**173**	**143**	2.08
DS Admiral	yes	1.8	2.0	6.9	**149**	130	1.87
	no	1.7	2.7	7.7	**173**	150	2.26
Susceptible							
Highlight	yes	2.0	2.1	6.8	**152**	**134**	2.33
	no	2.0	2.5	7.6	**170**	**156**	2.36
Alfetta	yes	2.2	2.4	7.6	**169**	**128**	2.94
	no	2.1	3.1	8.4	**193**	**151**	2.78
SW Salute	yes	2.1	2.0	6.7	**148**	**138**	2.43
	no	2.2	2.6	7.6	**173**	**154**	2.63
CDC Handel	yes	1.8	1.7	7.0	**145**	**135**	2.37
	no	1.8	2.3	7.7	**167**	**158**	2.38
Tolerant							
Carneval	yes	2.0	2.1	6.6	**148**	**116**	1.71
	no	2.0	2.7	7.3	**171**	**142**	1.59
LSD $_{(0.05)}$		0.24	0.30	0.51	9.1	9.0	0.415

Note: Means in bold type for AUDPC and Yield indicate significant differences at $P = 0.05$ within a cultivar.

Table B-2 Impact of fungicide (Bravo) application on severity of mycosphaerella blight (stem ratings, 0-9 scale), lodging and powdery mildew severity for cultivars with a range of reactions to mycosphaerella blight at Saskatoon in 2005.

Cultivar	Bravo appl.	Plants (m^{-2})	Severity on stems		Lodging	Powdery mildew
			Aug.15	Sept.09		
Partially resistant						
Nitouche	yes	30	2.9	7.3	5.0	2.0
	no	34	4.0	8.1	4.8	3.4
CDC Mozart	yes	43	3.7	6.9	4.0	0.0
	no	37	4.7	8.0	4.8	0.3
CDC Montero	yes	34	3.7	6.6	5.3	0.0
	no	29	4.3	7.2	5.5	0.2
DS Admiral	yes	30	3.6	6.8	4.3	0.0
	no	25	4.8	7.2	3.5	0.1
Susceptible						
Highlight	yes	38	3.6	7.1	4.8	0.0
	no	37	4.7	7.8	4.3	0.0
Alfetta	yes	42	3.1	7.1	3.5	1.7
	no	49	4.2	7.9	4.0	2.5
SW Salute	yes	39	3.9	7.2	4.3	0.0
	no	41	4.6	7.8	4.0	0.1
CDC Handel	yes	42	3.5	7.3	4.3	0.0
	no	38	4.4	8.2	4.3	0.1
Tolerant						
Carneval	yes	39	2.8	6.6	4.0	1.0
	no	35	4.0	7.4	5.0	1.9
LSD $_{(0.05)}$		13.7	0.56	0.52	1.83	0.35

Note: Lodging and severity of powdery mildew were assessed on August 15.

Table B-3. Impact of fungicide application on severity of mycosphaerella blight (whole plant ratings, 0-9 scale) and Area Under Disease Progress Curve (AUDPC) for selected field pea cultivars at Vegreville in 2005.

Cultivar	Bravo appl.	Mycosphaerella blight severity					AUDPC	Yield (kg/ha)
		Jul.06	Jul.13	Jul.22	Jul.29	Aug.03		
Partially resistant								
Nitouche	yes	0.3	1.0	2.3	2.9	2.9	51.2	0.87
	no	1.3	3.0	3.6	4.5	4.5	94.6	1.01
CDC Mozart	yes	0.6	1.6	3.0	3.2	3.2	**65.8**	**1.13**
	no	1.3	2.5	3.8	4.5	4.5	**93.6**	**1.70**
CDC Montero	yes	0.5	1.2	2.6	3.2	3.2	**58.9**	0.95
	no	1.2	2.7	3.9	4.3	4.3	**93.1**	1.02
DS Admiral	yes	0.6	1.1	2.5	3.1	3.1	**58.1**	0.68
	no	1.1	2.6	3.7	4.7	4.7	**94.3**	0.95
Susceptible								
Highlight	yes	0.6	1.8	3.1	3.3	3.3	**69.1**	1.05
	no	1.8	2.7	3.9	4.5	4.5	**96.8**	1.26
Alfetta	yes	0.2	0.8	2.0	2.1	2.1	**41.3**	1.42
	no	1.4	2.1	3.4	4.3	4.3	**85.1**	1.47
SW Salute	yes	0.5	1.5	2.9	2.9	2.9	**62.3**	1.12
	no	1.4	2.6	4.1	4.4	4.4	**95.7**	1.52
CDC Handel	yes	0.4	1.2	2.8	2.8	2.8	**56.9**	1.07
	no	1.2	2.6	3.8	4.5	4.5	**93.6**	1.19
Tolerant								
Carneval	yes	0.5	1.1	2.5	2.9	2.9	**55.1**	0.81
	no	1.4	2.7	3.9	4.8	4.8	**98.5**	1.05
$LSD_{(0.05)}$		0.32	0.61	0.40	0.49	0.49	10.05	0.432

Means in bold type for AUDPC and Yield indicate significant differences at $P = 0.05$ within a cultivar.

Table B-4 Impact of fungicide application on severity of mycosphaerella blight on stems (0-9 scale) and AUDPC of selected field pea cultivars at Vegreville in 2005.

Cultivar	Bravo appl.	Severity on stems					AUDPC (stems)
		Jul.06	Jul.13	Jul.22	Jul.29	Aug.03	
Partially resistant							
Nitouche	yes	0.00	0.2	1.5	1.6	1.6	**26.2**
	no	0.25	1.1	2.2	3.1	3.1	**53.8**
CDC Mozart	yes	0.00	0.4	1.4	2.4	2.4	**34.8**
	no	0.33	1.0	2.4	3.8	3.8	**59.8**
CDC Montero	yes	0.00	0.0	1.3	2.1	2.1	**28.3**
	no	0.18	0.9	2.7	3.7	3.7	**60.9**
DS Admiral	yes	0.00	0.1	1.3	2.4	2.4	**31.2**
	no	0.08	1.0	2.5	3.7	3.7	**59.3**
Susceptible							
Highlight	yes	0.00	0.4	1.6	2.2	2.2	**34.3**
	no	0.35	1.0	2.5	3.9	3.9	**61.8**
Alfetta	yes	0.00	0.0	1.0	1.0	1.0	**16.7**
	no	0.38	0.7	2.3	3.2	3.2	**52.7**
SW Salute	yes	0.00	0.3	1.1	1.6	1.6	**24.8**
	no	0.25	0.8	2.4	3.6	3.6	**56.9**
CDC Handel	yes	0.00	0.1	1.2	1.7	1.7	**24.2**
	no	0.18	0.9	2.2	3.7	3.7	**56.9**
Tolerant							
Carneval	yes	0.00	0.0	1.3	1.7	1.7	**24.2**
	no	0.28	1.0	2.2	3.6	3.6	**57.0**
LSD $_{(0.05)}$		0.18	0.20	0.38	0.49	0.49	7.24

Means in bold type for AUDPC indicate significant differences at $P = 0.05$ within a cultivar.

Table B-5. Seeding establishment (plants/m^2) and impact of fungicide application on severity of powdery mildew, and lodging on selected field pea cultivars at Vegreville in 2005.

Cultivar	Bravo appl.	Plants (m^{-2})	Powdery mildew	Lodging
Partially resistant				
Nitouche	yes	35	0.0	3.0
	no	34	0.8	3.0
CDC Mozart	yes	62	0.0	2.0
	no	60	0.0	2.0
CDC Montero	yes	38	0.0	3.0
	no	41	0.0	3.0
DS Admiral	yes	43	0.0	2.3
	no	42	0.3	2.5
Susceptible				
Highlight	yes	61	0.0	2.3
	no	57	0.3	2.3
Alfetta	yes	55	0.0	2.0
	no	57	1.3	2.8
SW Salute	yes	59	0.0	2.0
	no	63	0.0	2.3
CDC Handel	yes	55	0.0	2.8
	no	57	0.0	2.8
Tolerant				
Carneval	yes	41	0.0	2.5
	no	43	0.0	3.0
LSD $_{(0.05)}$		8.4	0.57	0.53

Note: Lodging assessed on July 29 and severity of powdery mildew on August 03.

Table B-6. Impact of foliar-applied fungicide on the severity of mycosphaerella blight (0-9 scale), area under the disease progress curve (AUDPC) on foliage and stems, and seed yield of field pea cultivars at Saskatoon, 2006.

Cultivar	Bravo appl.	Blight severity on foliage			AUDPC	AUDPC (stems)	Yield (Mg/ha)
		Jul.26	Aug.04	Aug.17			
Partially resistant							
Nitouche	yes	2.3	2.9	6.1	**81.5**	**54.7**	2.93
	no	2.6	3.4	6.4	**90.4**	**61.5**	2.50
CDC Mozart	yes	2.4	3.0	6.2	**83.3**	**59.2**	4.00
	no	2.8	3.6	6.7	**96.2**	**69.0**	3.43
CDC Montero	yes	2.4	2.9	5.9	**80.5**	**56.6**	3.34
	no	2.7	3.5	6.4	**92.0**	**69.4**	3.05
DS Admiral	yes	2.4	3.0	6.2	**84.0**	63.0	3.02
	no	2.7	3.6	6.4	**93.9**	67.9	2.67
Susceptible							
Highlight	yes	2.6	3.0	6.4	**86.5**	58.1	3.78
	no	2.8	3.5	6.7	**94.1**	57.0	3.44
Alfetta	yes	2.5	3.0	6.2	**84.5**	**52.5**	3.51
	no	2.9	3.6	6.7	**95.6**	**60.0**	3.44
SW Salute	yes	2.5	3.0	6.3	**85.4**	**58.9**	3.59
	no	3.0	3.7	6.8	**98.1**	**66.7**	3.62
CDC Handel	yes	2.3	3.0	6.0	**82.1**	58.1	3.31
	no	2.5	3.4	6.3	**89.6**	60.0	3.51
Tolerant							
Carneval	yes	2.4	2.9	6.0	**81.0**	**58.5**	2.95
	no	2.9	3.6	6.6	**95.3**	**66.4**	3.33
LSD $_{(0.05)}$		0.35	0.31	0.26	4.8	5.9	0.72

Note: Means in bold type for AUDPC and Yield indicate significant differences at $P = 0.05$ within a cultivar.

Table B-7. Impact of foliar-applied fungicide on the severity of mycosphaerella blight (stem ratings, 0-9 scale) and powdery mildew, and lodging of field pea cultivars at Saskatoon in 2006.

Cultivar	Bravo appl.	Plants (m^{-2})	Severity on stems		Powdery mildew (%)	Lodging
			Aug.02	Aug.17		
Partially resistant						
Nitouche	yes	59	2.9	4.4	60	0.5
	no	46	3.4	4.8	68	1.0
CDC Mozart	yes	70	3.1	4.9	0	3.5
	no	67	3.7	5.5	0	4.5
CDC Montero	yes	65	2.9	4.6	0	1.5
	no	59	3.5	5.8	3	2.5
DS Admiral	yes	62	3.0	5.4	0	0.0
	no	54	3.7	5.4	0	0.5
Susceptible						
Highlight	yes	78	3.1	4.7	0	4.0
	no	82	3.4	4.2	0	4.0
Alfetta	yes	70	3.0	4.0	15	2.5
	no	69	3.4	4.6	35	4.0
SW Salute	yes	73	3.0	4.9	0	2.5
	no	60	3.9	5.0	3	3.5
CDC Handel	yes	72	3.1	4.6	0	2.3
	no	70	3.3	4.7	0	2.8
Tolerant						
Carneval	yes	75	3.1	4.7	15	0.0
	no	68	3.7	5.2	15	0.5
LSD $_{(0.05)}$		10.0	0.5	0.9	15	2.0

Table B-8. Seedling establishment (plant/m^2) and impact of fungicide on severity of mycosphaerella blight (whole plant ratings, 0-9 scale), Area Under Disease Progress Curve (AUDPC), and seed yield of pea cultivars at Vegreville in 2006.

Cultivar	Bravo appl.	Plants (m^{-2})	Blight severity			AUDPC	Yield (Mg/ha)
			Jul.05	Jul.21	Aug.14		
Partially resistant							
Nitouche	yes	28.9	2.6	3.2	7.5	176	0.34
	no	21.0	2.8	3.6	7.7	187	0.34
CDC Mozart	yes	40.5	2.4	3.2	7.1	**168**	0.39
	no	34.5	2.2	4.3	7.0	**188**	0.35
CDC Montero	yes	18.3	2.3	2.9	6.9	**160**	**0.23**
	no	16.9	2.5	3.3	7.8	**181**	**0.53**
DS Admiral	yes	24.6	2.5	2.9	7.0	**162**	0.27
	no	24.5	2.4	3.8	7.6	**187**	0.36
Susceptible							
Highlight	yes	31.5	2.6	3.2	7.1	**171**	0.54
	no	33.1	2.9	3.9	7.9	**197**	0.40
Alfetta	yes	33.5	2.5	3.3	6.8	**169**	0.25
	no	37.8	2.7	4.0	7.4	**191**	0.36
SW Salute	yes	28.0	2.5	3.2	6.5	**163**	0.38
	no	32.5	2.6	3.7	8.1	**191**	0.41
CDC Handel	yes	39.8	2.7	3.0	7.0	**167**	0.43
	no	27.7	2.4	4.1	7.9	**196**	0.38
Tolerant							
Carneval	yes	29.5	2.0	3.2	6.6	**161**	0.22
	no	31.3	2.7	3.6	7.5	**184**	0.38
LSD $_{(0.05)}$		22.1	0.9	0.5	0.9	15.4	0.29

Note: Means in bold type for AUDPC and Yield indicate significant differences at $P = 0.05$ within a cultivar.

Table B-9. Impact of fungicide on severity of mycosphaerella blight (0-9 scale), AUDPC and seed yield for pea cultivars at Morden (site 1) in 2006.

Cultivar	Bravo appl.	Mycosphaerella blight severity					AUDPC	Yield (Mg/ha)
		Jul.17	Jul.23	Jul.31	Aug.07	Aug.13		
Partially resistant								
Nitouche	yes	1.2	2.0	2.2	2.5	2.7	60.7	2.89
	no	1.7	2.0	2.0	2.0	3.5	59.6	3.01
CDC Mozart	yes	1.0	1.5	2.0	2.0	3.2	**52.5**	4.72
	no	1.0	1.7	2.7	2.7	4.0	**67.1**	4.49
CDC Montero	yes	1.0	1.2	1.7	1.7	3.0	46.4	3.83
	no	1.0	1.5	2.0	2.0	3.5	53.2	4.36
DS Admiral	yes	1.2	1.7	2.0	2.2	4.0	**59.1**	3.22
	no	1.0	2.5	2.7	2.7	3.7	**72.0**	3.58
Susceptible								
Highlight	yes	1.2	2.0	2.0	2.0	2.5	**54.9**	3.17
	no	1.5	2.0	2.5	2.5	4.0	**67.2**	3.45
Alfetta	yes	1.7	2.0	2.0	2.0	3.7	60.4	3.74
	no	1.5	2.0	2.7	2.7	4.2	71.5	3.95
SW Salute	yes	1.7	2.0	2.2	2.5	3.0	63.2	3.81
	no	1.5	2.0	2.5	2.5	3.7	66.5	4.14
CDC Handel	yes	1.2	1.7	2.0	2.0	3.0	54.5	3.55
	no	1.0	2.0	2.2	2.2	3.5	60.5	3.23
Tolerant								
Carneval	yes	1.7	2.0	2.0	2.0	2.5	56.6	3.36
	no	1.2	2.0	2.5	2.5	3.7	65.6	2.51
LSD $_{(0.05)}$		0.69	0.71	0.66	0.75	0.79	11.51	1.00

Note: Means in bold type for AUDPC and Yield indicate significant differences at $P = 0.05$ within a cultivar.

Table B-10. Seedling establishment (plants/m^2), and impact of fungicide on lodging (% of stand lodged), and seed weight (per 200-seeds) of pea cultivars at Morden (site 1) in 2006.

Cultivar	Bravo appl.	Plants (m^{-2})	Lodging (%)	Seed wt. (g)
Partially resistant				
Nitouche	yes	50	25	43.4
	no	57	30	41.2
CDC Mozart	yes	51	47	41.2
	no	54	40	39.4
CDC Montero	yes	41	57	39.2
	no	40	62	36.9
DS Admiral	yes	44	17	40.3
	no	50	15	41.3
Susceptible				
Highlight	yes	46	20	30.4
	no	45	25	29.3
Alfetta	yes	55	22	45.9
	no	54	32	46.1
SW Salute	yes	58	32	36.4
	no	54	42	37.3
CDC Handel	yes	52	57	33.9
	no	52	52	34.7
Tolerant				
Carneval	yes	52	32	32.3
	no	61	27	28.2
LSD $_{(0.05)}$		17.3	16.4	1.95

Table B-11. Impact of fungicide on severity of mycosphaerella blight (whole plant ratings, 0-9 scale), AUDPC and seed yield of field pea cultivars at Morden (site 2) in 2006.

Cultivar	Bravo appl.	Mycosphaerella blight severity					AUDPC	Yield (Mg/ha)
		Jul.06	Jul.14	Jul.21	Jul.28	Aug.06		
Partially resistant								
Nitouche	yes	1.0	1.7	1.7	2.0	2.0	54.4	3.02
	no	1.0	1.7	2.0	2.0	2.0	56.1	2.51
CDC Mozart	yes	1.0	2.0	2.0	2.5	2.5	64.2	4.28
	no	1.0	2.0	2.0	2.0	2.2	59.1	3.75
CDC Montero	yes	0.5	1.7	1.7	2.0	2.0	52.4	4.13
	no	0.7	1.5	1.7	2.0	2.0	51.5	3.63
DS Admiral	yes	1.0	2.0	2.0	2.0	2.0	58.0	3.25
	no	1.0	2.0	2.0	2.0	2.0	58.0	2.92
Susceptible								
Highlight	yes	1.0	1.5	2.0	2.0	2.0	54.2	3.44
	no	0.7	1.5	2.0	2.0	2.0	53.2	3.34
Alfetta	yes	1.0	1.7	2.0	2.0	2.0	56.1	3.25
	no	1.0	1.7	2.0	2.5	2.5	62.4	3.08
SW Salute	yes	1.0	1.7	2.0	2.0	2.0	56.1	3.36
	no	1.0	2.0	2.0	2.5	2.2	61.1	3.10
CDC Handel	yes	1.0	2.0	2.0	2.0	2.0	58.0	3.70
	no	0.5	2.0	2.0	2.5	2.5	62.2	3.34
Tolerant								
Carneval	yes	1.0	1.7	2.0	2.0	2.0	56.1	3.37
	no	1.0	1.5	2.0	2.0	2.0	52.5	2.90
LSD $_{(0.05)}$		0.51	1.01	1.18	0.71	0.80	18.5	0.572

Note: Means in bold type for AUDPC and Yield indicate significant differences at $P = 0.05$ within a cultivar.

Table B-12. Seedling establishment (plants/m^2) and impact of fungicide on lodging (0-9 scale), and seed weight (per 200-seeds) of selected field pea cultivars at Morden (site 2) in 2006.

Cultivar	Bravo appl.	Plants (m^{-2})	Lodging	Seed wt. (g)
Partially resistant				
Nitouche	yes	57	40	**45.3**
	no	53	60	**42.1**
CDC Mozart	yes	58	60	39.8
	no	57	60	37.8
CDC Montero	yes	52	75	40.9
	no	44	75	40.9
DS Admiral	yes	49	37	42.2
	no	41	47	42.6
Susceptible				
Highlight	yes	52	55	31.3
	no	43	55	30.5
Alfetta	yes	56	72	**47.2**
	no	58	77	**45.0**
SW Salute	yes	59	72	36.8
	no	56	70	36.9
CDC Handel	yes	62	77	34.3
	no	54	72	34.1
Tolerant				
Carneval	yes	50	42	34.1
	no	52	42	34.1
LSD $_{(0.05)}$		19.3	13.4	2.23

Note: Means in bold type for seed weight indicate significant differences at $P = 0.05$ within a cultivar.

Table B-13. Seedling establishment (plants/m^2) and impact of fungicide (Headline) on severity of mycosphaerella blight (whole plant ratings, 0-9 scale), AUDPC and seed yield for pea cultivars at Saskatoon in 2007.

Cultivar	Fungi-cide	Plants (m^{-2})	Blight severity			AUDPC	Yield (Mg/ha)
			Jul.13	Aug.02	Aug.13		
Partially resistant							
Nitouche	yes	67	1.0	1.9	3.3	**57**	3.62
	no	69	0.8	4.4	5.4	**106**	3.48
CDC Mozart	yes	79	1.0	2.0	3.7	**62**	**4.26**
	no	78	1.3	4.8	6.0	**121**	**3.52**
CDC Montero	yes	76	1.2	2.2	3.6	**65**	3.51
	no	63	1.1	4.0	5.7	**104**	3.11
DS Admiral	yes	71	1.2	2.1	3.4	**63**	3.54
	no	75	1.0	4.2	5.5	**105**	3.36
Susceptible							
Highlight	yes	81	1.2	2.2	3.8	**67**	**4.04**
	no	79	1.3	5.2	6.3	**129**	**2.94**
Alfetta	yes	82	1.0	1.8	3.5	**57**	4.52
	no	70	1.1	4.6	6.1	**117**	4.00
SW Salute	yes	78	0.9	2.1	3.8	**63**	**4.31**
	no	79	1.0	4.3	6.0	**110**	**3.55**
CDC Handel	yes	72	1.0	1.7	3.5	**56**	3.57
	no	77	1.0	3.9	5.9	**103**	3.10
Tolerant							
Carneval	yes	80	1.2	1.9	3.1	**59**	2.97
	no	76	1.0	4.4	5.1	**106**	2.74
LSD $_{(0.05)}$		16.5	0.51	0.63	0.65	12.0	0.60

Note: Means in bold type for AUDPC and Yield indicate significant differences at $P = 0.05$ within a cultivar.

Table B-14. Impact of fungicide on severity of mycosphaerella blight on stems (0-9 scale), AUDPC for stem severity, lodging (0-9 scale), and severity of powdery mildew on pea cultivars at Saskatoon in 2007.

Cultivar	Fungi-cide	Severity on stems		AUDPC (stems)	Lodging	Powdery mildew
		Aug.02	Aug.13			
Partially resistant						
Nitouche	yes	1.6	2.7	**23.8**	0.0	1.3
	no	3.7	4.4	**44.5**	0.0	4.7
CDC Mozart	yes	2.1	3.1	**28.7**	2.9	0.0
	no	4.5	5.1	**52.8**	5.7	0.0
CDC Montero	yes	2.3	3.7	**33.4**	2.7	0.0
	no	4.0	4.8	**48.2**	3.6	0.0
DS Admiral	yes	2.1	3.5	**30.7**	0.0	0.0
	no	4.5	5.2	**53.6**	0.2	0.1
Susceptible						
Highlight	yes	2.4	2.9	**29.0**	2.2	0.0
	no	4.9	5.1	**55.3**	5.0	0.4
Alfetta	yes	1.4	2.8	**23.1**	2.0	0.0
	no	4.1	4.9	**50.0**	4.7	0.0
SW Salute	yes	1.9	3.3	**28.7**	3.2	0.0
	no	3.9	4.8	**48.0**	6.0	0.0
CDC Handel	yes	1.8	3.2	**27.9**	3.4	0.0
	no	4.8	5.2	**55.5**	5.8	0.0
Tolerant						
Carneval	yes	1.9	2.9	**26.6**	0.0	0.0
	no	4.4	4.8	**50.9**	0.7	0.0
LSD $_{(0.05)}$		0.77	0.61	6.54	2.80	0.45

Note: Powdery mildew severity was assessed on August 06 and lodging on Aug. 13. Means in bold type for AUDPC indicate significant differences at $P = 0.05$ within a cultivar.

Table B-15. Seedling density (plants/m^2) and impact of fungicide (Headline) on severity of mycosphaerella blight (whole plant ratings, 0-9 scale), AUDPC and seed yield of pea cultivars at Edmonton in 2007.

Cultivar	Fungi-cide	Plants (m^{-2})	Blight severity				AUDPC	Yield (Mg/ha)
			Jul.06	Jul.16	Jul.27	Aug.21		
Partially resistant								
Nitouche	yes	10	0.0	0.0	0.0	1.4	**18.1**	3.37
	no	15	0.0	0.1	0.7	4.5	**70.0**	3.47
CDC Mozart	yes	19	0.0	0.0	0.0	2.4	**30.6**	5.76
	no	15	0.0	0.4	0.9	4.5	**77.8**	6.00
CDC Montero	yes	12	0.0	0.0	0.0	1.9	**23.7**	3.92
	no	11	0.0	0.2	0.9	4.0	**69.4**	3.39
DS Admiral	yes	11	0.0	0.0	0.1	2.4	**31.8**	4.06
	no	14	0.1	0.2	1.0	4.7	**79.3**	4.82
Susceptible								
Highlight	yes	20	0.0	0.0	0.0	3.0	**37.5**	5.38
	no	15	0.1	0.2	1.0	4.5	**76.8**	5.57
Alfetta	yes	15	0.0	0.0	0.0	2.4	**30.0**	4.98
	no	10	0.1	0.1	1.0	5.2	**84.8**	4.63
SW Salute	yes	16	0.0	0.0	0.0	2.5	**31.9**	6.16
	no	13	0.1	0.4	1.0	4.7	**82.3**	5.81
CDC Handel	yes	19	0.0	0.0	0.0	2.3	**29.4**	**5.93**
	no	15	0.0	0.2	0.9	4.5	**75.7**	**4.94**
Tolerant								
Carneval	yes	16	0.0	0.0	0.0	2.4	**30.9**	3.83
	no	16	0.1	0.2	1.0	4.6	**79.3**	3.83
LSD $_{(0.05)}$		13.0	0.15	0.26	0.18	0.87	12.60	0.865

Note: Means in bold type for AUDPC and Yield indicate differences within a cultivar significant at $P = 0.05$.

Table B-16. Impact of fungicide on severity of mycosphaerella blight (whole plant ratings, 0-9 scale) on selected field pea cultivars at Morden in 2007.

Cultivar	Fungi-cide	Mycosphaerella blight severity					
		Jul.02	Jul.11	Jul.19	Jul.25	Aug.01	Aug.13
Partially resistant							
Nitouche	yes	0.7	1.2	2.0	2.2	2.5	3.5
	no	1.0	1.5	2.0	2.7	3.7	6.0
CDC Mozart	yes	1.0	1.7	2.0	2.0	3.0	4.0
	no	1.2	1.7	2.0	2.7	3.5	5.0
CDC Montero	yes	1.0	1.2	1.5	2.2	3.0	4.0
	no	1.0	1.2	2.0	2.7	3.2	4.5
DS Admiral	yes	0.7	2.0	2.0	2.2	3.5	4.7
	no	1.0	2.0	2.0	3.2	4.0	5.5
Susceptible							
Highlight	yes	1.0	2.0	2.0	2.5	3.2	4.5
	no	1.5	2.0	2.0	2.7	3.7	6.0
Alfetta	yes	1.0	1.7	2.0	2.2	4.0	5.0
	no	1.2	1.5	2.0	3.0	4.2	5.7
SW Salute	yes	1.0	1.7	2.0	2.0	3.5	4.2
	no	1.2	1.7	2.0	3.0	3.5	5.0
CDC Handel	yes	1.0	1.7	2.0	2.0	2.7	3.5
	no	1.0	1.2	2.0	2.7	3.7	4.2
Tolerant							
Carneval	yes	1.0	1.7	1.7	2.0	2.7	4.0
	no	1.5	1.5	2.0	2.7	3.2	4.5
LSD $_{(0.05)}$		0.64	0.70	0.32	0.61	0.70	1.11

Table B-17. Seedling establishment and impact of fungicide on severity of mycosphaerella blight (AUDPC, whole plant ratings), seed weight (per 200 seeds) and seed yield of field pea cultivars at Morden in 2007.

Cultivar	Fungi-cide	Plants (m^{-2})	AUDPC	Seed wt. (g)	Yield (Mg/ha)
Partially resistant					
Nitouche	yes	54	**75**	43.3	3.62
	no	64	**101**	43.2	4.03
CDC Mozart	yes	70	**85**	34.6	4.61
	no	69	**99**	35.1	4.16
CDC Montero	yes	61	79	**35.6**	4.65
	no	58	89	**33.5**	4.32
DS Admiral	yes	63	**94**	38.0	4.75
	no	73	**109**	37.8	4.51
Susceptible					
Highlight	yes	71	**94**	26.7	3.19
	no	76	**108**	26.5	3.24
Alfetta	yes	67	98	47.5	4.98
	no	70	107	46.0	4.57
SW Salute	yes	71	90	33.2	3.44
	no	67	100	31.5	3.57
CDC Handel	yes	67	81	31.3	3.46
	no	82	92	30.7	3.52
Tolerant					
Carneval	yes	71	**81**	30.9	3.69
	no	66	**94**	29.8	3.29
LSD $_{(0.05)}$		16.0	11.6	1.66	0.523

Note: Means in bold type for AUDPC and Yield indicate significant differences at $P = 0.05$ within a cultivar.

Table B-18. Impact of fungicide application (Bravo in 2005-06, Headline in 2007) on reduction in mycosphaerella blight severity (%) and increase in seed yield (%) at Saskatoon (Stoon), Vegreville (Vegr), Edmonton (Edm) and Morden (Mor) from 2005 to 2007.

Cultivar	2005		2006				2007		
	Stoon	Vegr	Stoon	Vegr	Mor 1	Mor 2	Stoon	Edm	Mor
				AUDPC					
Partially resistant									
Nitouche	22.5	85.9	11.1	7.0	-1.6	-1.7	87.4	320.7	34.6
CDC Mozart	12.5	43.3	15.6	11.9	28.3	-8.6	93.9	105.9	16.3
CDC Montero	13.2	58.2	14.1	14.2	19.7	-2.9	74.8	173.7	13.6
DS Admiral	16.4	64.1	11.9	16.0	26.9	0.0	68.8	205.7	16.1
Susceptible									
Highlight	12.0	40.0	9.0	16.2	23.0	-1.8	93.2	152.5	14.5
Alfetta	14.4	106.7	13.2	13.0	18.2	11.1	107.3	170.1	9.5
SW Salute	17.5	53.7	15.0	17.2	6.3	9.1	75.1	177.0	12.3
CDC Handel	15.4	64.3	9.3	18.1	11.0	7.2	82.6	184.7	14.4
Tolerant									
Carneval	15.2	78.7	17.6	15.0	15.7	-8.3	73.4	270.9	16.8
				Seed yield					
Partially resistant									
Nitouche	-6.7	-20.4	19.0	56.5	-2.2	24.1	4.2	-6.4	-12.2
CDC Mozart	19.1	-64.1	24.8	0.4	3.4	19.5	22.6	-3.1	11.9
CDC Montero	-0.1	-9.2	9.0	-69.1	-17.0	16.6	20.9	20.8	7.2
DS Admiral	-21.3	-42.4	16.8	-32.8	-11.5	10.4	5.8	29.5	5.4
Susceptible									
Highlight	-1.5	-21.9	9.9	-22.1	-9.5	7.3	38.1	- 4.7	-2.1
Alfetta	5.7	-33.8	2.1	-92.9	-5.9	21.8	12.5	-18.6	9.5
SW Salute	-8.3	-44.0	-0.6	-51.7	-9.2	10.9	21.5	3.9	-4.1
CDC Handel	-0.7	-10.6	-5.8	11.8	49.7	13.6	16.1	0.5	-1.7
Tolerant									
Carneval	7.2	-34.4	-13.0	-32.3	41.0	17.6	7.0	8.2	14.2

C. Reaction of accessions of *Pisum* spp. to mycosphaerella blight under field conditions

BACKGROUND: No strong sources of resistance to the ascochyta blight complex have been reported in field pea, despite repeated assessments of diverse sources of germplasm (Ali-Khan et al. 1973; Kraft et al. 1998; Xue and Warkentin 2001; Zhang et al. 2006). However, the reaction to mycosphaerella blight within and among field pea cultivars is surprisingly consistent among years and assessment techniques (Hwang et al 2006b) and the limited resistance that is available appears to be moderately heritable based on studies conducted as part of the larger study on resistance to mycosphaerella blight (Zhang and Gossen 2007; Zhang et al. 2007). This indicates that resistance would be a useful approach, despite the high genetic variability that is present in populations of *M. pinodes* (Xue et al. 1998). As a result, the search for sources of resistance has been expanded to include wild relatives of field pea (Muehlbauer et al. 1994). In a study in Australia, sources of resistance to mycosphaerella blight were found in some genotypes of *Pisum* spp. (Wroth 1998). In 2003, Dr. R. Conner (AAFC, Morden MB) obtained and increased the seed of numerous plant introduction (PI) accessions from USDA collections and lines from the USDA Plant Introduction Station in Washington (W)) of species closely related to field pea and conducted preliminary field screening of disease reaction at Morden in 2003. He provided seed of selected accessions for field tests at Morden and Saskatoon in 2004-07. The objective of this study was to assess the reaction of these lines to mycosphaerella blight under field conditions, with the intent of identifying lines that might have potential as sources of resistance to *M. pinodes*.

METHODS:

Field trials were conducted at the research farm of the Saskatoon Research Centre, AAFC, at Saskatoon SK on a heavy clay-loam soil from 2004-2005, and near the Morden Research Station, AAFC, at Morden, MB from 2004-2007. Each trial was arranged in a randomized complete block design, with two or three replicates per line, depending on seed availability. At Morden, the accessions were separated into two separate trials each year to minimize the variance that can occur across the length of a single large trial. In general, minimal fertilizer was applied, and weeds were controlled primarily by hand. Initially, each seed was scarified by chipping the seed coat with a scalpel prior to seeding. However, in 2005 this slow and labour-intensive approach was replaced with a TADD technique, which uses a machine that abrades the seed coat with a course stone surface. Each of the cups over the horizontal abrasive disc was filled with seed, leaving an opening the size of a dime. The machine ran at 1000 rpms for 5.8 seconds per batch of seed. Mycosphaerella blight severity was rated on a 0-9 scale (Xue et al., 1996) several times during the growing season. Powdery mildew was rated on the same scale when the disease developed, which was generally late in the growing season. The plots were hand-harvested as the plants matured. At Saskatoon, the seed was air-dried and then weighed to determine plot yield. At Morden, the seed was dried to approximately 15% moisture content before being weighed.

In 2004, 46 accessions that had been selected from trials conducted at Morden in 2003, as well as two commercial field pea cultivars, 'CDC Peko' (partially resistant check) and 'Topper' (highly susceptible check), were included at each site. The best lines were selected for further assessment from 2005-2007 (Table C-1). These selected lines were also assessed in 2005 using a detached-leaf inoculation technique (Hwang et al. 2006b) developed as part of the larger co-operative study that this research contributes to. Briefly, the upper portion (top four nodes) of four plants from each line was collected from the field plots at Saskatoon just prior to flowering and stored on ice in a portable cooler until they could be assessed. The two youngest fully expanded compound leaflets were excised from each plant, together with the central supporting

stem. Tendrils were cut in the same manner from samples without leaflets. Moist chambers were created by placing two moistened, autoclaved paper towels on the bottom of a 10-cm-diam. plastic Petri dish and covering them with a hard plastic mesh. The central stem section of a plant sample was placed through a hole in the plastic mesh to provide access to the water in the paper towels. The leaves or tendrils were inoculated with a 2 µL droplet of fresh conidial suspension (10^5 conidia mL^{-1} of isolate MP01-18-1-1 or MP01-40-1-1) at four sites on each leaflet. After incubation at 22 ± 1° C for 3 and 4 d, the resulting lesions were measured.

2004: At Saskatoon, the trial was planted on May 19. Pea seed was hand seeded (24 seeds m^{-1}) in 1-m-long rows, spaced 1.5 m apart, with two reps (due to a limited amount of seed). Crop residue from a field pea trial the previous year that had been heavily infected with mycosphaerella blight was spread within the plots on July 26. Plants at three locations in each plot were assessed for blight severity on August 6, 16 and 27. Plants were hand-harvested (late August-September) as the individual plots ripened to reduce seed loss due to shattering, but yields were highly variable, due in part to erratic germination and establishment.

At Morden, trial 1 was located at the Timmerman Field site, approximately 6 km east of the Research Station. The soil was sandy loam with bean stubble, and was prepared with a spring application of 23 lbs P_2O_5, 28 lbs K_2O and 3 lbs Cu per acre, and 8.9 kg/ac of Edge. There were 26 lines replicated three times in a RCBD design. The plots consisted of 2 rows, 3m in length, with 0.3 m row spacing and 0.3 m between plots. The trial was seeded on May 23. Weeds were controlled by hand rouging throughout the field season, and application of Basagran at 0.91 L/ac + Merge at 0.4 L/ac on June 28. An application of Poast at 0.19 L/acre + Merge at 0.4 L/acre also was made on June 28. Severity of mycosphaerella blight was rated on July 29, and August 7, 14 and 20.

In trial 2, each plot consisted of 2 rows, 2 m in length, with 0.3 m row spacing and 1.2 m between plots. The herbicide Edge had been applied the previous fall at 11.3 kg/ac. The trial was seeded on June 4 on a sandy-loam soil. Weeds were controlled by application of Poast at 0.2 L/ac + Assist at 0.4 L/ac on June 25 and July 15. The tests were inoculated with approximately 20 g per plot of chopped pea residue from a crop infected with *Mycosphaerella pinodes* on July 4. Severity of mycosphaerella blight was rated on August 16 and 23. Powdery mildew severity and the incidence of Fusarium wilt (%) were rated on August 16. On each date of disease severity rating, the growth stage of each plot was determined. The plots were harvested as the plants matured from the end of August to the middle of September.

2005: From the 46 pea accession lines assessed in 2004, 17 pea accessions, plus the checks ('CDC Peko', 'Topper') were selected for further evaluation. At Saskatoon, the trial was planted on June 13. Pea seed was seeded (24 seeds m^{-1}) in two 6-m-long rows with 0.3 m between rows and 0.6 m between plots in a randomized complete block design (RCBD) with three reps (occasionally only 2 reps due to limited seed). Pea residue infected with *M. pinodes* was spread in the plots on July 25. Ten plants in each plot were assessed for blight severity using a 0-9 rating scale (Xue et al. 1996) on August 8 and Sept. 7. On Sept. 7, disease severity was assessed on stems using a 0-9 scale, where 0 = no disease and 9 = stem girdled and dead or dying. Similarly, severity of powdery mildew (*Erisyphe pisi*) was rated on a 0-9 scale on Aug. 8, 16 and Sept. 7. Plots were harvested on Sept. 20.

At Morden, both trials were located at Morden, arranged in a RCBD design with three replications. The soil was heavy clay with cereal stubble, and was prepared with a spring application of fertilizer containing 30 lbs phosphate and 20 lbs sulfur and soil applied herbicide Treflan at 0.7 L/ac. Each plot consisted of 2 rows, 5m in length, with 0.3-m row spacing and 0.6 m between plots. The trials were seeded on May 17. Weeds were controlled by hand rouging

throughout the field season, and application of Basagran at 0.91 L/ac + Merge at 0.4 L/ac on June 18. Also, an application of Poast at 0.19 L/ac + Merge at 0.4 L/ac was made on June 19. Severity of mycosphaerella blight was rated on July 15 and 24. No further ratings were possible because the crop matured quickly in response to high temperature. There were 18 lines in Trial 1 and 14 lines in Trial 2.

2006–2007: The trial was only planted at Morden because seed supplies were not sufficient for trials at both locations. Pea seed was planted in two 6-m-long rows with 0.3 m between rows and 0.6 m between plots in a randomized complete block design with three reps. Ten plants in each plot were assessed for blight severity (0-9 scale) at each rating date.

In 2006, both trials were located at the Morden Nursery site 6 km east of Morden, MB, arranged as in 2005. The soil was loam clay with canola stubble seeded to winter wheat the previous fall. Soil preparations involved chemical and tillage control of the volunteer canola and winter wheat growth. Soil incorporated herbicide and fertilizer containing 100 lbs N and 30 lbs P per acre, plus 3 lbs of Cu fertilizer per acre according to soil test results. The trials were seeded on May 23. Broadleaf weeds were controlled with Basagran Forte at 0.9 L/ac and Merge adjuvant at 0.4 L/ac on June 19. Volunteer canola required a second application of Basagran and Merge at 0.7 and 0.4 L/ac respectively on June 26. Grassy weeds were further controlled by Poast Ultra at 0.4 L/ac with Merge at 0.4 only on June 15. Hand rouging was supplemented all season throughout the field. Pea aphid populations required control with Malathion 500EC at 0.9 L/ac on July 18 and 31. Severity of mycosphaerella blight was rated on July 17, 23 and 31, and August 7 and 13. Uniform plot dry down was promoted with an application of Reglone desiccant at 0.5 L/ac on August 21, and the plots were harvested on August 30. There were 18 lines in Trial 1 and 14 in Trial 2.

In 2007, the field trials were located at the Morden Research Station, MB, laid out as in 2005, but with four rows per plot and four replications. The well drained clay soil had cereal stubble. The field was prepared in the spring with a generic soil incorporated trifluralin herbicide (Bonanza), applied at 1.1 L/ac. In the fall of the previous year, fertilizer was applied at 70 lbs nitrogen, 20 lbs of phosphate and 11 lbs of sulfur per acre. The trials were planted on May 10. On June 19, 100 grams of infected pea residue was spread in each plot. Broadleaf weeds were controlled with Basagran Forte at 0.9 L/ac + Merge at 0.4 L/ac on June 14. Grassy weeds were controlled by Poast Ultra at 0.4 L/ac + Merge at 0.4 L/ac on June 19. Kumulus fungicide was applied in the field to control powdery mildew on July 24, and August 2 and 10. Pea aphid populations required control with Malathion 500EC at 0.9 L/ac on July 18 and 31. Disease severity of Mycosphaerella blight was rated on July 4, 11, 19, 25, and August 1, 9, 16 and 24. Reglone desiccant was applied on August 27 to speed the dry down of pea regrowth, and the plots were harvested on August 30. There were 18 lines in Trial 1 and 14 lines in Trial 2.

Analysis: Analysis of variance was conducted using the PROC GLM of SAS v.8. Significant differences between entries were tested using the least significant difference (LSD) multiple comparison test at $P \leq 0.05$. At Saskatoon, the area under the disease progress curve (AUDPC) was calculated as an approximation of the integral of the curve. At Morden, AUDPC was calculated using the following formula:

$$AUDPC = ((MB)/2))+((MB1+MB2)/2)+((MB2+MB3)/2)+((MB3+MB4)/2)+...)$$

where MB1 is the disease severity of Mycosphaerella blight on rating date 1, MB2 on rating date 2, etc. This approach provides a similar estimate of AUDPC to integration, as long as the interval between rating dates is constant.

RESULTS:

2004: Weather conditions were moderately conducive for the development of mycosphaerella blight at Saskatoon, and the most susceptible lines developed high levels of disease by the end of the season. There were very substantial differences among lines in mycosphaerella blight severity at Saskatoon (Table C-2), with several lines numerically superior to the resistant check, 'CDC Peko'. There was also a range of reaction to powdery mildew, with some accessions immune (0 rating), some partially resistant (0.5 rating) and some highly susceptible (rating of 1). There were large differences among the accessions for growth habit and yield (data not presented) and days to maturity (Table C-2). At Morden, disease levels were substantially lower and only one line was numerically superior to the resistant check (Table C-3).

2005: The TADD seed scarification technique was quicker, used less labour, and provided more uniform seed germination and seedling establishment than chipping the seed coat of each seed with a scalpel, so it was adopted as the standard approach for all subsequent tests.

At Saskatoon, conditions were moderately conducive for blight development and final disease levels were moderately high. There were small but significant differences in mycosphaerella blight severity (whole-plant ratings) among lines, with many of the lines substantially more resistant than the resistant check (Table C-4). However, it is interesting to note that severity on stems was generally lower in the check cultivars than in the accessions. Levels of powdery mildew were quite low initially (generally less that 2 on August 8, data not shown), but increased to moderate by August 16 and were high prior to harvest. Severity in all of the accessions was similar to those of the checks, both of which are highly susceptible.

At Morden, conditions were too dry for epidemic development of mycosphaerella blight, and so disease levels were low throughout the season (Table C-5). However, two of the accessions developed lower blight severity than the resistant check.

2006: Blight levels remained low at Morden throughout the growing season and none of the lines were better (developed less disease) than the resistant check (Table C-6).

2007: Blight levels were low initially, but increased to moderate levels late in the season. One line developed less disease than the resistant check (Table C-7).

Detached-leaf assessments: The accessions are arranged in the same order (Table C-8) as in Table C-4, where they occur in decreasing order based on foliar disease severity on the final rating date. Blight severity at Saskatoon in 2005 (summarized in Table C-4) was the highest that we experienced in the six station years of these assessments, and so likely represents the best testing environment for comparison with the detached-leaf technique. There was a weak association ($r = 0.35$) between the mean detached-leaf rating and AUDPC ratings at Saskatoon.

DISCUSSION AND CONCLUSIONS

There were no strong sources of resistance to mycosphaerella blight identified in the accessions that were examined in this project. However, many of the selected lines had disease reactions to *M. pinodes* as good as the partially resistant check 'CDC Peko'. Due to their diverse genetic background (expressed as a wide range of growth habit and plant architecture, flower colour, seed morphology, days to maturity, etc), it is likely that the selected lines carry some genes for resistance that differ from the resistance genes available in existing cultivars. It may be possible

to pyramid genes from these diverse sources together to produce lines with improved resistance to mycosphaerella blight. It is interesting to note that a high proportion of the lines that were selected for testing in 2005–2007 were *Pisum sativum* var. *arvense*. The high frequency of detectable levels of resistance in this close relative of field pea indicates that it may represent a source of resistance that could be incorporated into commercial cultivars. Another interesting observation was that there were substantial, consistent, and significant differences in blight severity between the resistant and susceptible checks across years and sites. This confirms that these two cultivars represent a useful range of variation in disease reaction for assessments in the region, even though the pathogen population is known to be highly diverse (Xue et al. 1998) and so likely differs between Saskatoon and Morden.

Even though the blight reaction of several accessions was as good or better than the (partially) resistant check at each location and each year, there were no lines that consistently performed as well as 'CDC Peko' across all six station years. Conditions during the growing season at Morden over the course of this study were drier than the long-term norm (Table A-1), and as a result, disease levels were unusually low for this site. Blight severity may not have been high enough to provide reliable assessments of disease reaction in the accessions. We believe that the dry conditions contributed substantially to the variability in disease assessments for individual accessions. However, the correlation between the reaction in the detached-leaf inoculation technique (conducted under controlled conditions) and blight severity assessments in the field when disease levels were high (Saskatoon in 2005) indicates that the search for sources of resistance (likely partial resistance) in relatives of field pea represents a promising avenue of investigation. Dr. Conner and co-workers have already completed crosses between many of these selected lines and commercial field pea cultivars (as part of the larger blight management program) and is currently advancing the breeding populations to ensure that they are genetically homogeneous. These breeding lines will be evaluated and selected, and then used as sources of resistance in subsequent breeding studies. Also, the correlation between the detached-leaf and field screening results supports the conclusion from companion studies that the detached-leaf assessment could be used as a pre-screen to eliminate highly susceptible lines before breeding material is tested in the field (Hwang et al. 2006b).

CONCLUSION

Many of the selected accessions of close relatives of field pea (especially those of *P. sativum* var. *arvense*) appear to have useful levels of resistance to mycosphaerella blight, but no strong sources of resistance were identified in these lines. Although we acknowledge that field screening is required to provide a final confirmation of results obtained via testing under controlled conditions, the dry conditions at Morden over the course of this trial increased the variability of results from field tests at that site, and may have masked the reaction of lines with useful levels of resistance. We conclude that testing under controlled conditions can be a useful approach for eliminating highly susceptible lines as part of the selection process in this system.

Table C-1. Selected pea accessions assessed for reaction to mycosphaerella blight.

Accession	Species/subspecies
CDC Peko	Check cultivar (res.)
Topper	Check cultivar (susc.)
PI343978	*Pisum sativum* subsp. *elatius*
PI343979	*P. sativum* subsp. *elatius*
PI344002	*P. sativum* subsp. *elatius*
PI344003	*P. sativum* subsp. *elatius*
PI344008	*P. sativum* subsp. *elatius*
PI344010	*P. sativum* subsp. *elatius*
PI344011	*P. sativum* subsp. *elatius*
PI358607	*P. sativum* subsp. *abyssinicum*
PI358608	*P. sativum* subsp. *abyssinicum*
PI358609	*P. sativum* subsp. *abyssinicum*
PI358613	*P. sativum* subsp. *abyssinicum*
PI358614	*P. sativum* subsp. *abyssinicum*
PI358615	*P. sativum* subsp. *abyssinicum*
PI358616	*P. sativum* subsp. *abyssinicum*
PI358617	*P. sativum* subsp. *abyssinicum*
PI358618	*P. sativum* subsp. *abyssinicum*
PI512070	*P. sativum* var. *arvense*
PI513252	*P. sativum* subsp. *elatius*
PI560055	*P. sativum* subsp. *elatius*
PI560056	*P. sativum* subsp. *elatius*
PI560057	*P. sativum* var. *pumilio*
PI560058	*P. sativum* subsp. *elatius*
PI560059	*P. sativum* subsp. *elatius*
PI560060	*P. sativum* subsp. *elatius*
PI560072	*P. sativum* var. *pumilio*
PI560968	*P. sativum* var. *arvense*
PI574505	*P. sativum* var. *arvense*
PI577142	*P. sativum* var. *arvense*

W615010	*P. sativum* subsp. *elatius*
W615012	*P. sativum* var. *pumilio*
W615020	*P. sativum* var. *pumilio*
W615039	*P. sativum* subsp. *asiaticum*
W615047	*P. sativum* var. *pumilio*
W611124	*P. sativum* subsp. *abyssinicum*
W612553	*P. sativum* var. *arvense*
W612613	*P. sativum* var. *pumilio*
W612615	*P. sativum* subsp. *elatius*
W612713	*P. sativum* var. *arvense*
W612733	*P. sativum* var. *arvense*
W612734	*P. sativum* var. *arvense*
W612737	*P. sativum* var. *arvense*
W615011	*P. sativum* subsp. *elatius*
W615015	*P. sativum* subsp. *elatius*
W615027	*P. sativum* subsp. *transcaucasicum*
W615028	*P. sativum* subsp. *transcaucasicum*
W615032	*P. sativum* subsp. *transcaucasicum*
W616220	*P. sativum* subsp. *elatius*

Table C-2. Severity of mycosphaerella blight (0-9 scale), area under the disease progress curve (AUDPC), severity of powdery mildew (0 = immune, 1= susceptible), and days to maturity of accessions of *Pisum* spp. at Saskatoon in 2004.

Line	Mycosphaerella blight severity			AUDPC	Powdery mildew	Day to maturity
	Aug.06	Aug.16	Aug.27			
CDC Peko (res.)	1.8	3.3	4.0	65	0	115
Topper (susc.)	3.3	3.8	6.0	89	0.3	115
W615039	4.5	7.5	7.0	140	0	79
W615020	3.0	7.0	8.0	133	0	86
PI358614	3.5	6.5	6.0	119	0	86
PI358617	3.5	6.5	6.0	119	0	79
PI3252	2.5	6.0	6.5	111	0	86
PI358615	3.5	4.5	6.5	101	0	83
PI344011	1.5	5.0	5.5	90	1.0	104
W616220	2.5	4.0	6.5	90	0.5	101
W615012	2.5	4.0	6.0	88	0.5	115
W615018	1.0	4.0	7.0	86	0	86
PI358607	2.0	4.0	6.0	85	0	115
PI358608	2.0	4.0	6.0	85	0.5	115
PI343979	2.0	4.0	5.5	82	0	93
PI577142	2.0	4.0	5.5	82	0.5	93
W615010	2.0	3.5	6.0	80	0	101
PI344003	3.0	3.0	5.0	74	0	115
PI120617	2.0	3.5	5.0	74	1.0	108
PI512061	1.0	4.0	4.5	72	1.0	115
PI560057	1.0	2.0	8.0	70	1.0	115
W615032	1.0	4.0	4.0	69	1.0	115
PI560072	1.0	4.0	4.0	69	0	115
PI512058	2.0	2.5	5.5	67	1.0	115
W615028	2.0	3.0	4.5	66	1.0	115
PI343978	1.0	3.0	5.0	64	0	86
W615040	2.0	2.5	5.0	64	0	115
W615047	1.5	2.5	5.5	64	0.5	115
PI560059	1.0	2.5	5.5	62	0.5	101

PI512059	2.0	3.0	3.5	61	0.5	115
PI560056	2.0	2.0	5.0	59	0	97
PI512067	2.0	2.5	4.0	58	0.5	114
PI512064	1.5	3.0	3.0	56	1.0	115
PI560060	2.0	2.5	3.5	56	1.0	108
W612713	1.5	3.0	3.0	56	1.0	115
W612733	1.5	2.5	4.0	56	0.5	115
W615027	1.5	2.5	4.0	56	1.0	115
PI560968	2.5	2.5	3.0	55	0.5	115
PI512063	2.0	3.0	2.0	53	0.5	115
W612553	1.5	2.0	4.0	51	1.0	115
PI512075	1.5	2.5	3.0	50	1.0	104
W6 11124	2.0	2.5	2.5	50	0.0	115
PI512070	1.5	2.0	3.5	48	0.5	115
PI512056	1.5	2.0	3.0	45	1.0	115
PI574505	1.5	1.5	2.5	37	0.5	114
LSD $_{(0.05)}$	1.3	2.2	2.6	32.5	NA	NA

Table C-3. Mycosphaerella blight severity (0-9), area under the disease progress curve (AUDPC) and mean growth stage for pea accessions at Morden in 2004.

Line/Cultivar	Mycosphaerella blight severity				AUDPC	Growth stage
	Jul.29	Aug.07	Aug.14	Aug.20		
Test 1						
CDC Peko (res.)	0.7	2.0	2.0	2.7	7.3	13.3
Topper (susc.)	2.0	3.0	3.0	4.7	12.7	13.6
PI343978	1.7	3.3	3.3	3.3	11.7	15.8
PI343979	1.7	2.7	3.3	3.3	11.0	15.7
PI344002	2.0	3.3	3.7	4.0	13.0	14.9
PI344003	2.0	3.0	3.7	3.7	12.3	13.6
PI344008	1.7	3.3	3.3	3.3	11.7	15.7
PI344010	1.3	2.7	3.7	4.0	11.7	14.1
PI344011	2.3	3.3	3.7	4.0	13.3	15.3
PI358607	2.0	2.7	3.0	3.0	10.7	15.8
PI358608	1.3	3.0	3.7	4.0	12.0	14.9
PI358609	2.7	3.0	3.7	4.0	13.3	15.6
PI358613	2.3	3.3	3.3	3.3	12.3	15.7
PI358614	1.7	2.7	3.3	3.3	11.0	15.8
PI358615	1.7	3.7	4.0	4.0	13.3	15.7
PI358616	2.3	3.7	3.7	3.7	13.3	15.8
PI358617	2.0	3.7	3.7	3.7	13.0	15.7
PI358618	2.0	3.3	3.3	3.3	12.0	15.7
PI513252	1.7	3.0	3.0	3.0	10.7	15.9
PI560055	1.3	2.7	3.3	3.7	11.0	13.6
PI560072	2.0	2.7	3.3	3.3	11.3	15.9
W615010	1.7	3.3	3.7	4.0	12.7	14.4
W615012	2.0	2.3	4.0	4.7	13.0	14.8
W615020	2.0	2.7	2.7	2.7	10.0	15.9
W615039	2.0	3.0	3.0	3.0	11.0	16.0
W615047	1.7	3.3	3.7	4.0	12.7	14.9
C.V.	27.3	20.4	18.0	15.8	14.2	1.9
LSD $_{(0.05)}$	0.82	1.01	1.00	0.93	2.76	0.48

Test 2						
CDC Peko	1.0	2.0	2.3	3.3	8.7	13.6
Topper	2.0	3.0	3.0	4.0	12.0	13.6
PI 512070	1.3	2.3	3.7	3.7	11.0	13.3
PI 560056	1.7	2.3	3.7	4.3	12.0	13.7
PI 560057	2.0	2.7	3.3	4.3	12.3	13.5
PI 560058	0.3	1.0	3.0	3.0	7.3	14.6
PI 560059	1.7	2.7	2.7	3.3	10.3	13.2
PI 560060	2.3	3.0	3.3	3.3	12.0	13.3
PI 560968	1.3	2.3	3.3	3.7	10.7	13.4
PI 574505	1.7	2.7	3.0	3.0	10.3	13.3
PI 577142	1.0	2.7	2.7	2.7	9.0	15.3
W611124	1.3	2.3	2.7	3.0	9.3	13.3
W612553	1.3	2.3	2.7	2.7	9.0	13.9
W612613	1.0	2.7	3.7	4.0	11.3	15.1
W612615	1.0	2.0	2.7	3.0	8.7	13.8
W612713	1.0	2.0	2.7	3.0	8.7	13.3
W612733	1.0	2.0	2.7	3.3	9.0	13.3
W612734	1.7	2.0	2.7	2.7	9.0	13.6
W612737	2.0	2.3	3.3	4.0	11.7	13.3
W615011	1.7	3.0	3.3	3.3	11.3	13.4
W615015	0.7	2.3	3.0	3.3	9.3	13.2
W615027	1.7	2.7	2.7	2.7	9.7	13.6
W615028	2.3	2.7	2.7	2.7	10.3	13.4
W615032	1.3	2.0	2.7	2.7	8.7	13.7
W616220	2.0	2.3	3.0	3.3	10.7	13.9
C.V.	36.6	23.8	22.2	17.8	17.8	1.5
LSD $_{(0.05)}$	0.87	0.93	1.09	0.97	2.95	0.35

Table C-4. Severity of mycosphaerella blight (whole plant and stem ratings, 0-9 scale), severity of powdery mildew (0-9 scale), and seed yield of selected pea accessions at Saskatoon in 2005.

Line/Cultivar	Blight severity		Severity on stems	Powdery mildew		Yield (Mg/ha)
	Aug.08	Sept.07	Sept.07	Aug.16	Sept.07	
CDC Peko (res.)	1.1	7.5	4.6	2.6	6.9	0.41
Topper (susc.)	2.7	8.1	6.9	2.8	6.6	1.17
PI 268480	2.7	8.2	8.6	2.7	5.3	0.38
W612734	2.8	7.8	6.6	3.3	7.1	0.28
PI 273279	2.3	7.8	3.4	2.8	5.9	0.27
PI 512065	2.8	7.1	7.4	3.4	7.2	0.17
W611124	1.9	7.3	5.1	2.2	6.6	1.00
W612733	2.0	7.2	6.4	3.6	6.8	0.53
W615043	2.0	7.1	6.2	3.0	5.7	0.16
PI 269761	1.9	7.2	5.0	3.5	6.5	0.35
PI 512061	2.0	7.0	7.7	4.2	5.8	0.41
PI 512056	2.0	6.9	5.9	4.0	7.4	0.46
W612713	2.0	6.8	5.8	3.5	7.0	0.50
W612615	3.0	6.8	8.2	2.7	5.6	0.05
W612553	2.1	6.5	6.5	3.7	6.9	0.12
PI 512067	1.7	6.4	7.3	3.6	6.5	0.47
W615032	3.3	6.3	5.2	2.6	6.0	0.08
PI 271936	1.2	6.2	5.9	2.6	6.4	0.15
PI 512063	0.9	6.2	7.8	3.1	6.0	0.12
LSD $_{(0.05)}$	1.1	0.7	1.6	0.7	1.5	0.56

Table C-5. Mycosphaerella blight severity (0-9 scale), AUDPC, and mean growth stage of selected pea accessions at Morden in 2005.

Line/Cultivar	Mycosphaerella blight		Growth stage
	Jul.15	Jul.21	
Test 1			
CDC Peko (res.)	2.0	3.7	14.0
Topper (susc.)	3.0	3.3	14.3
PI 268480	1.7	1.7	15.2
PI 269761	1.0	3.0	14.8
PI 343973	1.7	2.3	14.8
W612553	2.0	3.0	14.3
W612615	2.3	4.0	14.2
W612734	2.7	3.7	14.2
W612733	2.7	3.7	14.0
PI 512065	2.3	3.3	14.0
PI 512056	1.7	2.7	14.0
W612713	2.0	3.0	13.8
W611124	2.3	3.0	13.7
PI 512067	2.0	3.0	13.7
W615032	3.0	4.7	13.5
PI 273279	2.7	3.0	13.3
PI 271936	2.7	3.0	13.0
C.V.	26.6	25.0	2.4
LSD $_{(0.05)}$	0.98	1.33	0.55
Test 2			
CDC Peko	2.0	3.0	13.8
Topper	2.7	3.0	14.0
PI 512057	2.3	3.0	14.0
PI 512060	2.7	3.0	14.2
PI 512061	1.7	2.7	14.2
PI 512063	2.7	2.7	13.8
PI 512068	2.3	3.3	14.2
PI 512069	2.0	2.7	13.8
PI 512073	2.0	2.7	14.3
PI 512074	2.7	3.7	13.8
PI 512078	2.7	3.7	13.8
PI 512079	1.0	1.0	13.5
W615043	2.0	2.7	13.2
C.V.	21.6	23.5	2.7
LSD $_{(0.05)}$	0.80	1.12	0.64

Table C-6. Mycosphaerella blight severity (0-9), AUDPC, mean growth stage and seed yield of selected pea accessions at Morden in 2006.

Line/Cultivar	Mycosphaerella blight severity					AUDPC	Yield (Mg/ha)	Growth stage
	Jul.17	Jul.23	Jul.31	Aug.07	Aug.13			
Test 1								
CDC Peko (res.)	1.0	1.7	2.0	2.3	4.0	11.0	3.31	19.7
Topper (susc.)	2.0	3.0	3.7	3.7	4.7	17.0	3.77	13.7
PI 268480	2.0	2.7	3.0	3.0	4.7	15.3	1.29	14.1
PI 269761	2.0	3.0	3.0	3.0	4.7	15.7	2.91	13.5
PI 271936	2.0	2.7	3.0	3.0	5.0	15.7	2.83	13.0
PI 273279	1.7	2.7	3.0	3.0	4.0	14.3	2.63	12.9
PI 343973	2.0	2.7	3.0	3.0	5.0	15.7	0.29	13.7
PI 344012	1.7	2.0	2.7	3.0	4.0	13.3	0.01	13.3
PI 512056	2.0	2.7	3.0	3.0	4.7	15.3	0.67	12.9
PI 512065	1.7	2.0	2.7	3.0	4.3	13.7	1.09	12.9
PI 512067	1.7	2.3	3.0	3.0	5.7	15.7	0.84	13.0
W611124	1.7	2.7	3.0	3.0	4.3	14.7	3.32	12.9
W612553	2.0	2.3	3.0	3.0	4.0	14.3	1.14	13.4
W612615	1.3	2.0	2.3	2.7	3.7	12.0	0.09	13.3
W612713	1.3	2.3	2.7	2.7	5.3	14.3	0.86	12.7
W612733	1.7	2.3	2.7	2.7	5.0	14.3	1.91	12.8
W612734	2.0	2.7	2.7	3.0	4.7	15.0	3.11	13.6
W615032	1.3	1.7	2.0	2.3	3.7	11.0	0.08	13.5
C.V.	23.5	24.6	16.3	13.1	20.2	11.5	25.6	20.2
LSD $_{(0.05)}$	0.7	1.0	0.8	0.6	1.5	2.7	0.712	4.6
Test 2								
CDC Peko	1.3	2.0	2.7	2.7	3.7	12.3	2.90	13.1
Topper	2.0	2.0	2.7	2.7	4.7	14.0	3.13	13.6
PI 512057	1.7	2.0	2.3	2.3	5.0	13.3	0.94	13.1
PI 512060	2.0	2.0	2.3	2.3	4.3	13.0	4.15	13.7
PI 512061	1.0	1.3	1.7	1.7	1.7	7.3	0.16	14.7
PI 512063	2.0	2.0	2.0	3.0	5.0	14.0	2.17	13.1
PI 512068	1.7	1.7	2.3	2.7	5.7	14.0	1.03	12.9
PI 512069	1.0	1.7	2.0	2.0	4.7	11.3	1.47	13.0
PI 512073	1.3	1.7	2.0	2.0	4.3	11.3	2.14	13.2

PI 512074	2.0	2.0	3.0	3.0	5.7	15.7	1.10	13.3
PI 512078	1.3	2.7	3.0	3.0	5.3	15.3	1.32	13.4
PI 512079	1.0	1.0	2.3	2.3	4.3	11.0	0.44	13.0
PI 595932	1.0	2.0	2.0	3.0	4.0	12.0	0.12	13.2
W615043	1.3	2.0	2.3	2.3	5.0	13.0	2.50	12.9
C.V.	24.4	18.9	19.3	17.9	17.4	11.9	28.1	1.6
LSD $_{(0.05)}$	0.6	0.6	0.8	0.7	1.3	2.5	0.796	0.4

Table C-7. Mycosphaerella blight severity (0-9), AUDPC, mean growth stage and seed yield of selected pea accessions at Morden in 2007.

Cultivar	Mycosphaerella blight severity								AUDPC	Yield (Mg/ha)	Growth stage
	Jul.04	Jul.11	Jul.19	Jul.25	Aug.01	Aug.09	Aug.16	Aug.24			
Test 1											
CDC Peko	1.3	1.3	2.0	2.0	2.7	3.0	3.7	6.3	22.3	3.26	13.4
Topper	2.0	2.0	3.0	3.0	3.3	4.7	4.7	7.3	30.0	2.63	13.8
PI 268480	3.0	3.0	3.0	3.3	3.3	4.0	4.0	5.0	28.7	1.12	13.3
PI 269761	2.3	2.3	2.7	3.0	3.0	4.3	4.3	5.7	27.7	1.47	13.4
PI 271936	2.0	2.0	2.0	2.0	2.0	3.3	3.7	5.7	22.7	1.40	12.7
PI 273279	1.7	2.0	2.3	3.0	3.0	3.3	3.7	5.7	24.7	1.93	12.6
PI 343973	2.0	2.0	3.0	3.0	3.0	4.3	4.3	6.0	27.7	1.11	13.5
PI 344012	2.0	2.3	3.3	3.3	3.7	4.0	4.0	6.3	29.0	0.06	13.5
PI 512056	2.0	2.0	2.7	3.7	3.7	4.0	4.0	6.3	28.3	0.93	13.1
PI 512065	2.0	2.0	2.0	2.7	2.7	4.0	4.3	5.0	24.7	1.00	13.1
PI 512067	2.0	2.0	2.0	2.3	2.3	3.0	3.3	5.3	22.3	0.93	12.8
W611124	1.3	2.0	2.0	2.0	2.3	3.0	3.3	7.0	23.0	2.11	13.0
W612553	2.7	2.3	2.7	2.7	2.7	3.7	3.7	5.3	25.7	1.39	13.0
W612615	1.3	1.3	2.0	2.7	2.7	3.3	3.3	6.7	23.3	0.12	13.0
W612713	2.0	2.0	2.3	2.7	3.0	3.7	3.7	5.0	24.3	0.99	12.8
W612733	2.0	2.0	2.7	3.0	3.0	4.0	4.0	7.3	28.0	1.96	13.2
W612734	2.0	2.0	3.0	3.0	3.0	3.3	3.3	5.7	25.3	1.96	13.6
W615032	2.0	2.3	2.7	3.0	3.0	3.3	3.7	6.7	26.7	0.91	12.8
C.V.	17	16	18	14	15	15	15	15	7.9	15.8	1.1
LSD $_{(0.05)}$	0.6	0.5	0.8	0.7	0.7	0.9	0.9	1.5	3.4	0.37	0.2
Test 2											
CDC Peko	1.0	1.3	1.7	2.3	2.7	3.3	3.3	5.7	21.3	2.86	13.1
Topper	2.0	2.3	3.0	3.3	4.0	4.3	4.7	7.0	30.7	2.80	13.7
PI 512057	2.0	2.0	2.3	2.3	2.3	4.0	4.3	6.7	26.0	0.95	13.2
PI 512060	1.3	1.7	2.0	2.7	3.0	4.0	4.0	5.3	24.0	1.54	13.7
PI 512061	1.3	1.7	2.0	2.3	2.3	3.0	3.3	4.7	20.7	0.50	13.3
PI 512063	2.0	2.0	2.7	3.0	3.3	4.3	4.7	6.7	28.7	1.34	13.3
PI 512068	2.0	2.0	2.3	3.0	3.0	3.7	3.7	4.3	24.0	1.39	13.1
PI 512069	1.7	2.0	2.3	2.7	3.0	3.3	3.7	5.0	23.7	0.99	13.3
PI 512073	1.3	1.7	2.0	2.7	2.7	3.3	4.0	4.3	22.0	1.70	13.5
PI 512074	1.3	1.7	2.0	2.3	2.3	4.0	4.0	5.0	22.7	0.81	13.6
PI 512078	1.7	1.7	2.3	2.3	2.3	3.3	4.0	5.3	23.0	0.66	13.8
PI 512079	0.3	0.7	1.3	1.3	1.3	2.0	2.0	2.7	11.7	0.55	13.2
PI 595932	3.0	3.0	3.7	4.0	4.0	4.3	4.3	5.7	32.0	0.11	14.1
W615043	1.0	1.7	2.0	2.3	3.0	3.3	4.0	6.3	23.7	1.15	12.9
C.V.	27	26	23	20	16	19	15	17	10.0	29.3	1.2
LSD $_{(0.05)}$	0.7	0.8	0.9	0.9	0.8	1.1	1.0	1.5	4.0	0.61	0.3

Table C-8. Reaction of selected accessions of *Pisum* spp. to inoculation with two isolates of *Mycosphaerella pinodes* in a detached-leaf assay (n = 10).

Accession	Isolate (Lesion diameter in mm)				Mean (Day 4)
	MP01-18-1-1		MP01-40-1-1		
	Day 3	Day 4	Day 3	Day 4	
CDC Peko (res.)	1.8 g	4.0 h	1.2 f	3.5 ef	3.8
Topper (susc.)	3.0 c-e	7.8 b-d	2.5 b-d	7.2 bc	7.5
W615032	6.0 a	10.0 a	4.1 a	9.6 a	9.8
PI 269761	3.5 bc	9.3 ab	2.2 c-e	8.0 ab	8.7
PI 273279	4.1 b	9.1 ab	2.8 bc	7.4 bc	8.3
PI 268480	3.9 b	8.9 ab	3.1 b	7.7 b	8.3
PI 271936	3.5 bc	8.1 bc	1.7 d-f	4.8 de	6.5
W615043	3.3 b-d	7.6 b-d	1.8 d-f	4.2 de	5.9
PI 512061	2.9 c-f	6.0 d-g	1.7 d-f	5.7 cd	5.9
PI 512067	2.4 d-g	7.0 c-e	1.5 ef	4.1 de	5.6
W612615	2.4 d-g	6.7 c-f	1.6 ef	4.3 de	5.5
PI 512056	2.6 c-g	7.0 c-e	1.5 ef	3.2 ef	5.1
W612713	2.6 c-g	7.7 b-d	1.1 f	2.1 f	4.9
W612733	2.4 d-g	6.2 d-f	1.1 f	3.4 ef	4.8
PI 512063	2.3 e-g	5.2 f-h	2.5 b-d	4.4 de	4.8
W611124	2.3 e-g	6.1 d-g	1.3 f	3.4 ef	4.8
W612734	2.2 e-g	5.8 e-g	1.5 ef	3.8 d-f	4.8
PI 512065	2.0 fg	4.4 gh	2.5 b-d	4.3 de	4.4
W612553	2.5 d-g	5.1 f-h	1.3 f	3.0 ef	4.1

* Means in a column followed by the same letter do not differ based on Duncan's New Multiple Range Test at $P = 0.05$.

D. Disease reaction of field pea cultivars and processing pea varieties

BACKGROUND: In a trial conducted in Alberta as part of the larger program on blight management in field pea, the reaction of field pea lines to mycosphaerella blight was assessed over two years using three techniques (inoculation of field trials with conidia of a single isolate, inoculation of intact plants in a greenhouse, and inoculation of detached leaves) on a range of commercial field pea cultivars produced in western Canada (Hwang et al. 2006). Most of the cultivars exhibited an intermediate reaction using all three techniques, but the variation in results within and among techniques for individual lines was quite high. However, the reaction of lines at the high severity(= highly susceptible) and low severity (= partially resistant) end of the reaction scale was much more consistent. The objective of this trial was to assess (and potentially validate) the results of this study by assessing the disease reaction of cultivars identified as partially resistant versus highly susceptible under field conditions at sites where the pathogen population was likely to be as different as possible from that the one assessed in the initial study in Alberta. A number of processing pea lines were also included in the trial to assess their reaction to mycosphaerella blight and powdery mildew.

METHODS: Trials were established at two sites, one at the research farm of the AAFC Research Centre at Saskatoon SK and the other at Muck Research Station of the University of Guelph at Bradford ON. Each test consisted of four dry pea cultivars (partially resistant = 'Radley', 'Carneval'; susceptible = 'Montana', 'Miami', occasionally 'Express' was included as well) and up to 20 processing pea varieties; seven lines from Seminis (Cabro, Estancia, Ice Breaker, Durango, Early Sweet 414, Lil'Mo, Paso), five from Crites-Moscow (Senaca 516, CMG 307F, Kelly, Jaguar, Samish), three from Stokes (Mr. Big, Bolero, Utrillo), three from Pure Line (PLS 116, PLS 285, Legacy), and one each from Brotherton (Case Lode), Rogers (Genie), and Sharpes International (Gemini). The area under the disease progress curve (AUDPC) was often calculated to summarize disease development over time. Analysis of variance (General Linear Model Procedure of SAS) was used to analyse blight severity of whole plants and stems, AUDPC, powdery mildew severity, lodging and yield.

At Saskatoon, pea seed was direct seeded (20-25 seed m^{-1}) using a double-disc drill seeder. A randomized complete block design with four replications was used, and each plot was 6.0 x 1.2 m (3.0 m in 2004). Each plot consisted of four 6-m-long rows, spaced 30 cm apart, with 60 cm between plots. The plots were irrigated as required to enhance disease infection and spread. Ten plants from three locations within each plot were assessed for blight severity (0 - 9 scale). Lodging was assessed (0-9 scale, Table A-3) prior to harvest, developed from a scale for pea suggested by Wang et al. (2006).

At sites in Ontario, each plot consisted of eight 6-m-long rows, spaced 20 cm apart with 1.5 m between plots. Pea seed was direct seeded (20-25 seed /m) using an Earthway push seeder. Plots were hand-harvested (1 m^2 per plot) because there was no suitable small-plot equipment at this site. The test was not irrigated or inoculated.

2004: At Saskatoon, five dry pea cultivars (partially resistant = 'Radley', 'Carneval'; susceptible = 'Express', 'Montana', 'Miami') and three processing pea varieties (Gemini, Cabro, Genie, disease reaction unknown) were planted on May 18. Pea seed was direct seeded (20-25 seed m^{-1}) using a double-disc drill seeder. Pea residue heavily infected with mycosphaerella blight was spread within the pea plots on July 26. Blight severity was assessed on August 6, 16 and 27.

In southern Ontario, five processing pea varieties, Mr. Big, Cabro, Genie, Bolero and Estancia, were planted on May 13 and three field pea cultivars, 'Miami', 'Express' and 'Montana', were planted on May 18 on a mineral soil at Bradford. In addition, six processing pea

varieties, Mr. Big, Genie, Bolero, Estancia, Gemini and Paso, were planted on May 18 and three dry pea cultivars, 'Radley', 'Montana' and 'Miami', were planted on June 03 near Wellington, ON in Prince Edward County on a sandy soil with low organic content. The trials were not inoculated. Ascochyta blight was assessed at plant maturity at Prince Edward County on July 26, and ascochyta and powdery mildew were assessed at Bradford on July 23 and 30.

2005: At Saskatoon, the test was planted on May 30. Pea crop residue that was heavily infected with mycosphaerella blight was spread in the plots on July 20. Blight severity was assessed on August 19 and Sept. 07. Severity of powdery mildew was rated on a visual percent of plants affected on Aug. 19. The trial was selectively harvested on Sept. 08 and 20-22, due to differences in maturity among cultivars.

At Bradford, the test (four dry pea and 20 processing pea lines) was planted on May 6 and assessed for blight severity (10 plants per plot) on July 11, 14 and 18.

2006: At Saskatoon, the test was planted on May 17. Pea crop residue that was heavily infected with mycosphaerella blight was spread in the plots on July 11. Blight severity was assessed on July 26 and August 10. On Aug. 11, blight severity was assessed on stems using the 0-9 scale. Severity of powdery mildew was rated as percent leaf area affected on Aug. 14. Lodging of the cultivars was rated on Aug. 15 (0-9 scale). The trial was selectively harvested on Aug. 15 and 28, due to differences in maturity among cultivars.

At Bradford, the test (four dry pea and 20 processing pea lines) was planted on May 6 and assessed for blight severity (10 plants per plot) on July 11, 14 and 18.

Detached-leaf assessments: The blight reaction of each variety/cultivar was assessed using the detached-leaf technique describe in Section C, using plant material collected from the field trial at Saskatoon in 2005. The upper portion (top four nodes) of four plants from each line was collected from the field plots at Saskatoon just prior to flowering and stored on ice in a portable cooler until they could be assessed. The two youngest fully expanded compound leaflets were excised from each plant, together with the central supporting stem. Tendrils were cut in the same manner from samples without leaflets. Moist chambers were created by placing two moistened, autoclaved paper towels on the bottom of a 10-cm-diam. plastic Petri dish and covering them with a hard plastic mesh. The central stem section of a plant sample was placed through a hole in the plastic mesh to provide access to the water in the paper towels. The leaves or tendrils were inoculated with a 2 µL droplet of fresh conidial suspension (10^5 conidia mL^{-1} of isolate MP01-18-1-1 or MP01-40-1-1, selected in preliminary screening for high levels of aggressiveness) at four sites on each leaflet. After incubation at 22 ± 1° C for 3 and 4 d, the resulting lesions were measured.

RESULTS:

2004: Weather conditions at Saskatoon in 2004 were quite conducive for disease - slightly cooler and substantially wetter than normal (Table A-2). At the first rating date, blight severity was low (mean = 2.1) and there were no differences among the cultivars (Table D-1). At the second date, disease levels were still low (mean = 3.3); severity in the partially resistant cultivars ('Carneval' and 'Radley') was lower than 'Miami' and 'Montana', and most of the processing lines, but did not differ from Express and Gemini. At the final rating, severity had increased substantially (mean = 6.2), and severity was lower in the resistant cultivars (plus Express) than the other lines in the trial. The resistant cultivars had significantly lower AUDPC than most other lines. Express and Gemini also had lower AUDPC than the most susceptible lines.

Significant differences in disease severity were observed at both sites in Ontario (Table D-2). At Wellington and Bradford, Mr. Big had significantly higher blight severity than all other varieties. At Bradford, powdery mildew severity was higher on Estancia than the other varieties, where as Genie and Mr. Big had less disease than the other varieties. Processing pea varieties differed in susceptibility to ascochyta blight and to powdery mildew. The processing lines that were comparatively resistant to ascochyta tended to be susceptible to powdery mildew, except for Bolero, which was susceptible to both diseases.

2005: Weather conditions at Saskatoon were quite conducive for disease - cooler and wetter than the long-term norm (Table A-2). At the first rating date, blight severity was low (mean = 1.2) and there were no differences among the lines, but differences among the genotypes were apparent at the second rating date (mean = 3.9, Table D-3). By the final date, disease levels were high (mean = 7.4). The susceptible field pea cultivar 'Miami' had the highest level of disease, and several processing varieties, including Samish and Bolero, were also highly susceptible. There were also differences in disease reaction to powdery mildew. Lines fell into one of three statistically distinct groups; 'Miami' (4.9) was the most susceptible line, there was a group of moderately susceptible lines with ratings between 1.5 and 3.4, and a resistant group (0.2 - 0.6).

At Bradford, blight severity was extremely low (Table D-4) and no powdery mildew was observed, likely due to dry hot conditions during the growing season. Discoloured lesions were observed on some plants, but *Ascochyta* spp. could be isolated from only a few of these lesions. These lesions tended to be more severe on the varieties Bolero, Ice Breaker, Early Sweet 414, Samish, and CMG 307F, and least severe on cvs. 'Radley', 'Montana' and Paso, but differences were small and not considered to be biologically important.

2006: Weather conditions at Saskatoon in the spring of 2006 were wetter than the long-term norm, but conditions in July were hot and dry (Table A-1), which was not conducive for development of mycosphaerella blight. At the first rating date, blight severity was low (mean = 2.0) and there were no differences among the lines. At the second rating date, levels of mycosphaerella blight had increased to moderate levels and there were differences among the genotypes (mean = 5.9, Table D-5). The susceptible field pea cultivar 'Montana' had a higher level of disease than the resistant line 'Carneval', and several processing varieties, including Early Sweet, CMG 307F and Utrillo were more susceptible than the susceptible field pea lines. There were differences in susceptibility to powdery mildew among lines (Table D-6), and substantial differences in seed yield.

At Bradford, levels of mycosphaerella blight was low, but severity on cv. 'Radley' was lower than in 'Miami' (Table D-7). There was a substantial increase in severity of both mycosphaerella blight and powdery mildew over the short intervals between the first and last rating.

Detached-leaf assessments: There was no clear association between the response of lines in the field trials and in these assessments under controlled conditions (Table D-8).

DISCUSSION AND CONCLUSIONS

Differences in disease reaction among the field pea cultivars were consistent across years and sites. Mycosphaerella blight was more severe on the field pea cultivars previously identified as highly susceptible ('Miami', 'Montana') than on the partially resistant lines ('Radlley', 'Carneval'). This pattern of reactions to mycosphaerella blight supports our previous report on the disease reaction of these cultivars (Hwang et al. 2006). More importantly, it demonstrates

that the resistance of these lines did not differ between the initial trial in Alberta where the susceptible and resistant designations were assigned, and the field locations in Saskatchewan and Ontario where the present study was conducted. The absence of a clear association between the results of field ratings and detached-leaf assays was unexpected, based on our previous work (Hwang et al. 2006) and results in Section C.

The processing pea varieties differed in susceptibility to mycosphaerella blight in this study. Results of the field screening were quite consistent; the varieties Mr. Big, Bolero and Genie generally had higher blight severity than Estancia, Paso and Gemini. However, it is unlikely that there are novel sources of resistance in these processing lines that have not already been identified in field pea cultivars. In contrast, there were also significant and consistent differences in severity of powdery mildew among the processing lines, which have not been reported previously and will be of particular and immediate interest to producers (e.g., under irrigation in southern Alberta).

Table D-1. Severity of mycosphaerella blight (0-9 scale) , area under the disease progress curve (AUDPC) and seed yield of pea cultivars and varieties at Saskatoon, 2004.

Variety/ Cultivar	Mycosphaerella blight severity			AUDPC	Yield (Mg/ha)
	Aug.06	Aug.16	Aug.27		
Processing pea					
Gemini	2.3 a	2.5 b	6.3 b	72 cd	0.97 de
Cabro	1.8 a	4.3 a	8.1 a	99 a	0.68 e
Genie	2.3 a	4.1 a	7.8 a	97 a	1.13 de
Field pea					
Radley	1.8 a	2.7 b	4.9 d	64 d	1.37 cd
Carneval	1.9 a	2.7 b	4.9 d	65 d	1.89 bc
Express	2.1 a	2.4 b	5.3 cd	65 d	1.03 de
Montana	2.2 a	3.7 a	6.0 bc	83 bc	2.25 ab
Miami	2.2 a	4.1 a	6.6 b	90 ab	2.65 a
Standard error	0.1	0.2	0.2	2.9	0.14

(*a - d*) Means in a column followed by the same letter are not significantly different at $P = 0.05$ based on the Waller-Duncan K-ratio t test.

Table D-2. Severity of mycosphaerella blight and powdery mildew (calculated as AUDPC) on lines of processing and dry pea at two sites in Ontario in 2004.

Variety/ Cultivar	Type	Mycosphaerella blight		Powdery mildew
		Wellington	Bradford	Bradford
Mr. Big	Processing	5.5 a	28.2 a	0.9 f
Cabro	Processing	--	17.8 b	16.6 de
Genie	Processing	4.2 b	17.6 b	1.8 f
Bolero	Processing	2.8 c	20.4 b	25.4 bc
Estancia	Processing	2.1 c	10.5 c	35.9 a
Gemini	Processing	2.0 cd	--	--
Paso	Processing	1.1 d	--	--
Miami	Dry	--	8.8 c	28.9 b
Express	Dry	--	7.8 c	21.0 cd
Montana	Dry	--	7.1 c	13.2 e
SE		0.33	2.67	3.2
Radley	Dry	1.5 a	--	--
Montana	Dry	1.2 b	--	--
Miami	Dry	1.1 b	--	--
SE		0.07		

(*a-d*) Means in a column followed by the same letter do not differ at $P = 0.05$ based on Fisher's Protected LSD test.

Note: The dry pea cultivars at Wellington were seeded later than the other lines, so were separated for statistical analysis

Table D-3. Disease severity (0-9 scale) of mycosphaerella blight and powdery mildew, and seed yield of pea cultivars and varieties at Saskatoon, 2005.

Variety/ Cultivar	# Plants (m^{-1} row)	Powdery mildew severity	Mycosphaerella blight		Seed yield (Mg /ha)
			Aug.19	Sept.07	
Processing pea					
Bolero	12.9	1.6	4.0	7.8	0.5
CMG 307F	11.9	1.7	4.3	7.2	0.34
Cabro	5.8	2.0	4.1	7.1	0.18
Case Lode	5.3	2.0	4.2	6.3	0.11
Durango	13.8	0.2	3.5	6.7	0.52
Early Sweet	14.1	1.8	5.0	7.2	0.18
Estancia	13.9	3.4	4.5	7.2	0.58
Gemini	10.4	2.5	4.2	7.2	0.24
Genie	10.4	0.3	4.0	7.8	0.7
Ice Breaker	10.1	0.6	5.0	7.2	0.17
Jaguar	7.6	0.3	4.1	8.0	0.26
Kelly	9.5	0.3	3.5	8.0	0.38
Legacy	10.8	0.4	3.8	7.0	0.25
Lil Mo	9.6	1.8	4.0	7.1	0.29
Mr. Big	12.3	0.3	3.6	8.1	0.6
PLS 062	10.8	0.5	3.4	7.0	0.64
Paso	7.4	2.9	3.3	7.5	0.56
Samish	9.5	1.9	3.8	8.0	0.55
Senaca 516	10.1	3.2	4.1	7.9	0.4
Utrillo	12.8	2.0	3.8	7.9	0.41
Field pea					
Carneval	7.6	1.7	3.5	6.7	0.54
Radley	10.6	3.3	3.7	7.2	0.73
Miami	12.8	4.9	4.3	8.2	0.96
Montana	10.5	2.9	3.5	7.2	0.44
$LSD_{(0.05)}$	3.4	0.9	0.7	0.4	0.46

Note: Severity of powdery mildew was assessed on August 19.

Table D-4. Seedling establishment (plants/m row), severity of mycosphaerella blight and powdery mildew (0-9) and seed yield of processing and dry pea lines at Bradford, ON in 2005.

Variety/ Cultivar	Plants (m^{-1} row)	Powdery mildew	Mycosphaerella blight		Yield (Mg /ha)
		Aug.19	Aug.19	Sept.07	
Processing pea					
Bolero	12.9	1.6	4.0	7.8	0.50
CMG 307F	11.9	1.7	4.3	7.2	0.34
Cabro	5.8	2.0	4.1	7.1	0.18
Case Lode	5.3	2.0	4.2	6.3	0.11
Durango	13.8	0.2	3.5	6.7	0.52
Early Sweet	14.1	1.8	5.0	7.2	0.18
Estancia	13.9	3.4	4.5	7.2	0.58
Gemini	10.4	2.5	4.2	7.2	0.24
Genie	10.4	0.3	4.0	7.8	0.70
Ice Breaker	10.1	0.6	5.0	7.2	0.17
Jaguar	7.6	0.3	4.1	8.0	0.26
Kelly	9.5	0.3	3.5	8.0	0.38
Legacy	10.8	0.4	3.8	7.0	0.25
Lil'Mo	9.6	1.8	4.0	7.1	0.29
Mr. Big	12.3	0.3	3.6	8.1	0.60
PLS 062	10.8	0.5	3.4	7.0	0.64
Paso	7.4	2.9	3.3	7.5	0.56
Samish	9.5	1.9	3.8	8.0	0.55
Senaca 516	10.1	3.2	4.1	7.9	0.40
Utrillo	12.8	2.0	3.8	7.9	0.41
Field pea					
Carneval	7.6	1.7	3.5	6.7	0.54
Radley	10.6	3.3	3.7	7.2	0.73
Miami	12.8	4.9	4.3	8.2	0.96
Montana	10.5	2.9	3.5	7.2	0.44
$LSD_{(0.05)}$	3.35	0.94	0.71	0.39	0.464

Table D-5. Disease severity (0-9 scale) of mycosphaerella blight on foliage and stems, and area under the disease progress curve (AUDPC) of pea cultivars and varieties at Saskatoon, 2006.

Variety/ Cultivar	# Plants (m^{-1} row)	Blight severity		AUDPC	Severity on stems Aug.11
		Jul.26	Aug.10		
Processing pea					
Bolero	21.1	2.0	6.0	60.6	5.0
CMG 307F	21.9	2.3	6.8	67.7	5.8
Cabro	14.1	2.1	5.7	58.5	4.2
Case Lode	12.8	2.2	6.2	63.2	5.8
Durango	25.0	1.5	6.3	58.5	5.4
Early Sweet	25.5	3.0	7.3	77.3	5.3
Estancia	24.1	2.5	5.6	60.6	5.1
Gemini	24.1	2.2	5.5	57.9	5.0
Genie	19.6	1.9	5.6	56.6	5.3
Ice Breaker	19.6	2.9	6.2	68.4	5.1
Jaguar	19.3	2.1	6.6	65.4	5.2
Kelly	20.8	1.6	5.5	53.4	5.1
Legacy	22.9	1.8	6.5	62.4	5.6
Lil'Mo	22.9	2.0	6.1	61.1	4.7
Mr. Big	19.0	1.6	6.3	59.6	5.5
PLS 116	16.9	1.5	6.1	56.6	5.2
Paso	17.6	1.5	4.8	47.4	4.2
Samish	19.4	1.8	6.1	59.3	5.5
Senaca 516	22.5	2.1	5.3	55.5	4.5
Utrillo	23.1	1.8	6.7	63.6	5.0
Field pea					
Carneval	26.1	1.6	4.7	47.6	5.0
Radley	24.6	1.7	5.4	53.6	4.1
Miami	24.3	2.3	5.2	56.6	4.3
Montana	22.9	1.5	5.4	51.9	4.0
LSD $_{(0.05)}$	5.0	0.6	5.0	9.3	0.8

Table D-6. Severity of powdery mildew (% leaf area affected), lodging, plant stand, and seed yield of pea cultivars and varieties at Saskatoon in 2006.

Variety/ Cultivar	Powdery mildew (%)	Lodging (0-9)	Plant stand (m^{-2})	Yield (Mg/ha)
Processing pea				
Bolero	68	8.0	70.3	1.77
CMG 307F	48	7.5	72.8	1.65
Cabro	65	7.5	47.0	0.83
Case Lode	73	7.0	42.5	0.98
Durango	30	8.0	83.3	1.43
Early Sweet	40	9.0	84.9	1.74
Estancia	8	4.5	80.3	2.94
Gemini	45	6.0	80.3	2.19
Genie	0	7.0	65.4	1.99
Ice Breaker	50	7.5	65.4	1.24
Jaguar	8	7.5	64.1	1.61
Kelly	0	7.5	69.1	1.17
Legacy	13	7.0	76.2	1.85
Lil'Mo	43	5.5	76.2	2.21
Mr. Big	5	7.0	63.3	0.55
PLS 116	10	7.0	56.2	1.30
Paso	38	3.0	58.7	2.30
Samish	63	6.5	64.5	1.56
Senaca 516	76	3.5	74.9	1.72
Utrillo	81	7.5	77.0	0.98
Field pea				
Carneval	30	1.0	87.0	2.71
Radley	82	3.5	82.0	2.39
Miami	52	0.8	80.8	2.34
Montana	35	3.5	76.2	2.87
LSD $_{(0.05)}$	15	1.6	16.6	0.89

Table D-7. Severity of mycosphaerella blight and powdery mildew (0-9 scale) on pea cultivars and varieties at Bradford ON in 2006.

Variety	Mycosphaerella blight			AUDPC	Powdery mildew			AUDPC (mildew)
	Jul.11	Jul.14	Jul.18		Jul.11	Jul.14	Jul.18	
Processing pea								
Bolero	1.6	2.6	2.7	16.9 l	0	0	0	0.0 a
CMG 307F	1.3	2.7	1.8	17.8 kl	0	0.7	1.4	5.4 abc
Cabro	0.8	1.2	0.9	7.2 b-f	0	0.5	1.1	3.9 ab
Case Lode	1.2	2.4	1.6	13.5 j-l	0	0	0.1	0.3 a
Durango	0.4	0.5	1.3	5.0 a-d	0	0	2.1	4.3 ab
Early Sweet	0.9	1.2	0.9	7.2 b-f	0	0	0.7	1.5 ab
Estancia	1.5	2.1	2.1	13.7 j-l	0.1	1.8	2.3	10.9 c
Gemini	1.4	1.7	2.2	12.4 h-k	0	0.4	0.6	2.8 ab
Genie	0.7	1.1	2.0	8.9 d-i	0	0	0	0.0 a
Ice Breaker	1.1	2.2	1.4	12.2 g-k	0	0.2	0.4	1.5 ab
Jaguar	1.1	2.2	1.8	12.9 i-k	0	0	0	0.0 a
Kelly	0.8	1.1	1.7	8.3 c-g	0	0	0	0.0 a
Legacy	1.2	1.7	1.5	10.8 f-k	0	0	0	0.1 a
Lil'Mo	0.6	1.4	1.3	8.5 c-h	0	0	0.1	0.1 a
Mr. Big	0.9	1.7	1.5	10.0 e-j	0	0	0	0.0 a
Paso	0.3	0.5	0.9	3.8 ab	0	0.2	0.5	1.8 ab
PLS 116	0.8	1.6	1.8	10.6 f-j	0	0.1	0	0.2 a
PLS 285	0.7	1.4	0.9	7.6 d-f	0	0.5	0.6	2.9 ab
Samish	1.2	1.8	2.2	12.3 g-k	0	0.3	0.8	2.5 ab
Utrillo	0.8	1.1	1.7	8.4 c-h	0	0	1	1.9 ab
Field pea								
Carneval	0.4	1.1	0.9	6.0 a-e	0	0	1.3	2.8 ab
Radley	0.3	0.5	0.5	3.1 a	0	0.3	3.2	7.3 bc
Miami	0.5	0.7	1.5	6.2 a-e	0	1.1	1.4	6.6 bc
Montana	0.4	0.5	1.1	4.7 a-c	0	0.2	0.9	2.3 ab
LSD $_{(0.05)}$	0.6	1.0	0.8		0	1.1	1.9	

Table D-8. Pea cultivar susceptibility to two isolates of *Mycosphaerella pinodes* using the detached-leaf assay (n = 10).

Variety/Cultivar	Mycosphaerella isolate (Lesion diameter in mm)*			
	MP01-18-1-1		MP01-40-1-1	
	Day 3	Day 4	Day 3	Day 4
Processing pea				
Early Sweet 414	3.8 a	8.2 a	2.0 a-d	5.3 ab
Samish	3.2 ab	6.4 cd	2.0 a-d	4.6 a-d
Lil'Mo	3.0 bc	6.4 cd	2.5 a	4.9 a-c
Legacy	2.9 bc	5.8 c-f	1.3 d	3.6 c-f
CMG 307 F	2.8 b-d	8.0 ab	2.2 a-c	4.7 a-c
Estancia	2.8 b-d	6.7 bc	2.4 ab	5.8 a
Jaguar	2.8 b-d	6.3 cd	1.9 a-d	5.1 a-c
Bolero	2.7 b-e	5.5 c-f	1.6 b-d	3.0 d-f
Genie	2.7 b-e	4.3 f-i	2.5 a	5.4 ab
Kelly	2.7 b-e	5.0 d-g	2.0 a-d	5.0 a-c
Case Lode	2.6 b-f	5.6 c-f	1.6 b-d	4.5 a-d
Cabro	2.6 b-f	4.9 d-h	1.8 a-d	4.1 b-e
Utrillo	2.5 b-f	5.4 c-f	2.1 a-d	4.2 a-e
Ice Breaker	2.5 b-f	4.5 f-i	2.0 a-d	4.2 a-e
Senaca 516	2.5 b-f	5.6 c-f	2.4 ab	5.2 a-c
Durango	2.2 c-g	4.5 f-i	1.9 a-d	4.1 b-e
Paso	2.0 d-h	3.1 ij	nd	nd
PLS 062	1.8 f-h	5.2 c-g	1.4 cd	2.5 f
Mr. Big	1.8 f-h	4.7 e-h	1.3 d	4.2 a-e
Gemini	1.2 h	2.4 j	1.5 cd	2.8 ef
Field pea				
Carneval	1.5 gh	3.5 hij	1.5 cd	4.9 abc
Montana	2.1 c-g	4.6 f-i	2.2 abc	4.2 a-e
Miami	1.3 h	3.7 g-j	1.7 a-d	3.9 c-f
Radley	1.9 e-h	6.2 cde	1.6 bcd	3.6 c-f

(a-*j*) Means in a column followed by the same letter do not differ based on Duncan's New Multiple Range Test at $P = 0.05$.
nd = not done.

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Xue, A.G., Charest, J., Davidson, C.G., McAndrew, D.W., Bing, D.J., and Warkentin, T.D. 2003. Response of field pea cultivars to chlorothalonil in the control of mycosphaerella blight. Can. J. Plant Sci. 83: 313-318.

Zhang, R., Hwang, S.F., Chang, K.F., Gossen, B.D., Strelkov, S., Turnbull, G.D., and Blade, S.F. 2006. Genetic resistance to *Mycosphaerella pinodes* in 558 field pea accessions. Crop. Sci. 46: 2409–2414.

TECHNOLOGY TRANSFER

Reports and presentations have been provided to producers, papers and posters have been presented at scientific conferences, and several papers from the larger co-operative program have been already been published and others are in preparation.

PERFORMANCE INDICATORS

Impact

The results of this work are of primary interest to pea breeding programs, which require this information to develop cultivars with improved resistance to mycosphaerella blight. Several papers have already been published in scientific journals, and so are available to breeding programs around the world. Other papers are still in development, and will be submitted in the coming year. However, the results of these studies are being shared with breeders across Canada at meetings and conferences. For example, Dr. Gossen presented these results as the focus of invited seminars at the Harrow Research Centre AAFC, to the Plant Agriculture Department at the University of

Guelph, and at the Saskatoon Research Centre of AAFC in 2008, and will provide copies of the summary report to pea breeders at AAFC Lacombe and the University of Saskatchewan as soon as they have been approved by ADF.

Benefits

The information developed in this research program will be used by plant breeders to improve disease resistance breeding in field pea, and to reduce yield and quality losses caused by mycosphaerella blight. Reducing losses from disease improves profitability and income stability for individual growers and the industry as a whole.

Human resources

Two students were hired each summer to assist with the establishment, maintenance, assessment and harvest of the field plots (one at Saskatoon, the other at Morden).

New technology

1) Scientists in this study developed a detached-leaf assessment technique that provides a quick and inexpensive approach to assess the disease reaction of field pea lines, and have validated this approach on accessions of *Pisum* spp. They have also developed a selection technique that uses toxins from the pathogen on detached leaves, but this approach has not yet been validated with field testing.
2) BASF used the data from the trials to support a Minor Use registration of Headline for control of mycosphaerella blight on processing pea.
3) Accessions of close relatives of pea were assessed for blight reaction, and genes for resistance from several of the best lines are being back-crossed into adapted field pea cultivars.
4) Published results from previous work (Wang et al. 2006) showing that the severity of mycosphaerella blight is strongly affected by crop lodging.
5) Estimates of the heritability of quantitative resistance to mycosphaerella blight (Zhang et al. 2006; Zhang and Gossen 2007), and estimates of the number of genes for resistance in several of the most resistant lines available (Zhang et al. 2007) were developed and published.
6) The disease reaction of various plant accessions and processing pea varieties to powdery mildew was assessed and made available to growers in reports and presentations.

PUBLICATIONS

Refereed publications

Gossen, B.D., and Hwang, S.F. 2005. Pea diseases: Ecology and control. In Pimental, D. (*Editor*) Encyclopedia of Pest Management. Marcel Dekker Inc. Available on-line at www.dekker.com.

Hwang, S.F., Conner, R.L., Chang, K.F., Gossen, B.D., Su, H., Howard, R.J., and Turnbull, G.D. 2006. Impact of seeding rate and depth on mycosphaerella blight and seed yield of field pea. Can. J. Plant Sci. 86: 845–853.

Hwang, S.F., Zhang, R., Chang, K.F., Gossen, B.D., Turnbull, G.D. and Bing, D.J. 2006. Comparison of three methods for assessing disease reaction to *Mycosphaerella pinodes* in field pea (*Pisum sativum*). J. Plant Dis. Prot. 113: 20–23.

Wang, T.F., Gossen, B.D., and Slinkard, A.E. 2006. Lodging increases severity and impact of mycosphaerella blight on field pea. Can. J. Plant Sci. 86: 855–863.

Zhang, R., Hwang, S.F., Chang, K.F., Gossen, B.D., Strelkov, S., Turnbull, G.D., and Blade, S.F. 2006. Genetic resistance to *Mycosphaerella pinodes* in 558 field pea accessions. Crop. Sci. 46: 2409–2414.

Zhang, R., and Gossen, B.D. 2007. Heritability estimates and response to selection for resistance to mycosphaerella blight in pea. Crop Sci. 47: 2303–2307.

Zhang, R., Hwang, S.F., Gossen, B.D., Chang, K.F., and Turnbull, G.D. 2007. A quantitative analysis of resistance to *Mycosphaerella pinodes* in *Pisum sativum*. Crop Sci. 47: 161–167.

Other Scientific

McDonald, M.R., Celetti, M., Boland, G., Gossen, B., and Roddy, E. 2005. Management of ascochyta blight on processing peas. Final Report to the Ontario Processing Vegetable Growers. London, ON. 12 pp.

Melzer, M.S., Roddy, E., Celetti, M.J., McDonald, M.R., Gossen, B.D., Vander Kooi, K., and Boland, G.J. 2005. Ascochyta blight of processing pea in southwestern Ontario in 2004. Can. Plant Dis. Surv. 85: 100 – 101 (published on diskette).

Abstracts and Proceedings

McDonald, M.R., Gossen, B.D., Celetti, M.J., and Boland, G.J. 2007. Severity of powdery mildew on succulent and dry pea lines. Can. J. Plant Pathol. 29: 211.

Wang, H., Hwang, S.F., Kharbanda, P., Watson, P., Gossen, B.D., and Howard, R.J. 2007. Evaluating pea genotypes for resistance to powdery mildew in Alberta. Can. J. Plant Pathol. 29: 212.

Zhang, R., Hwang, S.F., Chang, K.F., Gossen, B.D., and Turnbull, G.D. 2006. Quantitative analysis of resistance to *Mycospheraella pinodes* in *Pisum sativum*. Can. J. Plant Pathol. 28: (in press).

Chang, K.F., Hwang, S.F., Bowness, R.T., Gossen, B.D., Turnbull, G.D., McLaren, D.L., Conner, R.L., and Bing, D.J. 2006. Host range and cultivar response to fusarium root rot of field pea. Pg. 38 in Proc 6 Can. Pulse Res. Workshop, Saskatoon, SK. Nov 1–3, 2006.

Hwang, S.F., Chang, K.F., Gossen, B.D., Conner, R.L., Turnbull, G.D., and Bing, D.J. 2006. Impact of plant age on mycosphaerella blight [*Mycosphaerella pinodes*] in field pea. Can. J. Plant Pathol. 28: 353.

McDonald, M.R., Gossen, B.D., Celetti, M.J., Roddy, E., and Boland, G.J. 2006. Timing and efficacy of fungicides for the management of ascochyta blight on processing peas. Can. J. Plant Pathol. 28: 359.

McLaren, D.L, Conner, R.L., Hwang, S.F., Gossen, B.D., Mohr, R.M., Chang, K.F., and Bing, D.J. 2006. Impact of oat plants, oat plant extracts and saponins on *Fusarium solani* f.sp. *pisi*. Pg. 42 in Proc 6 Can. Pulse Res. Workshop, Saskatoon, SK. Nov 1–3, 2006.

Wang, H., Hwang, S.F., Chang, K.F., Gossen, B.D., Turnbull, G.D., and Howard, R.J. 2006. Reaction of excised pea leaves to crude extracts from *Mycosphaerella pinodes*, and detection of metabolites of the pathogen using thin-layer chromatography. Can. J. Plant Pathol. 28: 367–368.

Wang, T.F., Gossen, B.D., and Slinkard, A.E. 2006. Crop lodging increases severity of ascochyta blight in field pea. Proc. 1st Intern. Ascochyta Workshop on Grain Legumes, July 2–6, 2006. Le Tronchet, France.

Celetti, M.J., McDonald, M.R., Gossen, B.D., Vander Kooi, K., Melzer, M.S., Roddy, E., and

Boland, G.J. 2004. Susceptibility of processing and dry pea varieties and efficacy of fungicides on ascochyta blight. Proc. 5th Canadian Pulse Res. Workshop, London, ON, November 2004. Also presented at the Ont. Pest Management Conf., Guelph ON, November 2004, and Ont. Fruit and Vegetable Conf., St. Catherines ON, February 2005.

Celetti, M.J., McDonald, M.R., Gossen, B.D., Vander Kooi, K., Melzer, M.S., Roddy, E., and Boland, G.J. 2005. Susceptibility of processing and dry pea varieties and efficacy of fungicides on ascochyta blight. Can. J. Plant Pathol. 27: 170.

Gossen, B.D., Buchwaldt, L., Kutcher, H.R., and Chongo, G. 2005. Decision support systems for management of foliar blight on lentil and field pea in western Canada. Pg. 93 in Proc. 9t Intern. Workshop on Plant Disease Epidemiology. Intern. Soc. Plant Pathol., Landerneau, France, April 11–15, 2005.

Hwang, S.F., Chang, K.F., Conner, R.L., Gossen, B.D., Howard, R.J., Turnbull, G.D., and Bing, D.J. 2005. Impact of seeding and disease initiation dates on seed yield and severity of mycosphaerella blight in field pea. Can. J. Plant Pathol. 27: 470.

Hwang, S.F., Conner, R.L., Gossen, B.D., Su, H., Howard, R.J., and Turnbull, G.D. 2005. Seeding conditions: Potential for management of mycosphaerella blight of field pea. Can. J. Plant Pathol. 27: 146–147.

Wang, T.F., Gossen, B.D., and Slinkard, A.E. 2005. Impact of lodging and foliar fungicide on severity of mycosphaerella blight and yield in field-pea lines. Can. J. Plant Pathol. 27: 480.

Hwang, S.F., Zhang, R., Chang, K.F., Gossen, B.D., and Turnbull, G.D. 2004. Comparison of three methods for assessing reaction to *Mycosphaerella pinodes* in lines of *Pisum sativum*. Can. J. Plant Pathol. 26: 414.

Technology Transfer

Gossen, B.D. 2008. Mycosphaerella blight of pea: Pathologists (and breeders) never give up. Invited seminars presented at Harrow Research Centre, AAFC, on Feb. 26, 2008, University of Guelph, Plant Agriculture Department, Feb. 27, and Saskatoon Research Centre, AAFC, March 3, 2008.

Wang, T.F., Gossen, B.D., and Slinkard, A.E. 2007. Crop lodging increases severity of ascochyta blight in field pea. Pg. 64 in The business of farming: Pulse days 2007. SK Pulse Growers, Jan 8–9, 2007, Saskatoon, SK.

Gossen, B.D. 2006. Identification and management of pulse crop diseases. Invited presentation, Western Crop and Pest Management School, Dickinson, ND, Feb 2, 2006.

Gossen, B.D. 2005. Ascochyta blight of pea. Invited paper presented at the Ontario Processing Vegetable Industry Conf. London, ON, January 25, 2005.

McDonald, M.R., Celetti, M., Melzer, M., Gossen, B.D., Roddy, E., and Boland, G. 2005. Management of ascochyta blight of processing peas. Paper presented at the Ontario Processing Vegetable Industry Conf. London, ON, January 25, 2005.

Celetti, M.J., McDonald, M.R., Gossen, B.D., Vander Kooi, K., Melzer, M.S., Roddy, E., and Boland, G.J. 2004. Susceptibility of processing and dry pea varieties and efficacy of fungicides on ascochyta blight. Poster presented at the 5th Can. Pulse Res.Workshop, London, ON, November 2004.

(C) Personnel

	FTE (per year)	Cost to Project
Professional		
- B.D. Gossen	0.2 PY	-
- R. Conner (AAFC Morden)	0.1	-

- S.F. Hwang (AAFRD, Edmonton)	0.1	-
- K.F. Chang (AAFRD, Lacombe)	0.1	-
- M.R. McDonald, U of G	0.1	-
Technical		
- K. Bassendowski	0.3 PY	-
- Other technical staff	0.2 PY	-

Summer and Casual
- Two assistants were hired each summer to support the field program

(d) Equipment - none

(e) Photos - A limited number of the pictures used in presentations and posters are available upon request.

(f) Acknowledgements - SPG and ADF were acknowledged in all presentations and publications.

(g) Public Information Materials - This report will be the main publication available to the general public, but all of the scientific publications are available in the scientific literature.

(I) Deliverables for evaluation

Numerous publications on diseases of field pea have been prepared, submitted and published in scientific journals. In addition, presentations have been made at extension meetings and scientific conferences (see publications section).

Expenditures

A statement of expenditures for the project will be provided under separate cover.